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# The vegetation of the Canadian Prairie Provinces
# IV. The woody vegetation, Part 4
# Coniferous forests

by J. LOOMAN, Swift Current

with 6 photos and 5 tables

**Abstract.** The coniferous forests occupy the Boreal forest zone of the Prairie Provinces and much of the submontane-subalpine zone of the eastern slope of the Rocky Mountains in Alberta, covering a total area of approximately 1 200 000 km$^2$. These forests are of considerable economic importance, and produce large amounts of lumber and pulpwood. Because of the large number of lakes suited for recreational purposes, communities in the Boreal forest zone derive much of their income through tourism, especially hunting and fishing. The forests also are the habitat of a large but diminishing number of fur bearing animals, and are of considerable economic importance to fur trappers.

The coniferous forests of Canada have several species, varieties, or vicariants of species in common with their Eurasian counterparts, and can be placed in the existing class Vaccinio-Piceetea, order Pino-Piceetalia. Based on analyses of 882 relevés, and for some areas the study of existing literature, three new alliances, with 8 associations and 27 subassociations are described, and several variants are mentioned.

Further research is needed, and will probably show the existence of several other forest communities, or lead to the elevation of most of the subassociations to the status of associations. The ecology and the significance as biocoenose of the forests, as well as their economic importance, are discussed.

## Introduction

The coniferous forests of the Prairie Provinces are the largest single vegetation type, occupying approximately 1 200 000 km$^2$. Most of this forest is in the Boreal forest zone, and continues north into the North West Territories. The submontane-subalpine coniferous forests of the Rocky Mountains in Alberta, however, are also of considerable extent, with an area of more than 100 000 km$^2$, or almost 10 % of the total area.

Three basic types of coniferous forest can be distinguished, each characterized by one or more tree species, and often also several species of shrubs and herbs, as well as bryoids. These three vegetation types also occupy different habitat types.

The most common type of coniferous forest, occupying about 45 % of the total area, is that dominated by, or with a significant cover of, the white spruce,



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*Picea glauca*, represented in the Rocky Mountains by var. *albertiana*. It is widespread, and occurs on all soil types but usually occupies soils of medium to heavy textures. The balsam fir, *Abies balsamea* (or *A. lasiocarpa* in the mountains) is more or less abundant in the most highly developed forms.

Second in area is the bog forest, dominated by the black spruce, *Picea mariana*, often accompanied by *Larix laricina*. It is most common in successional seres on muskeg areas, and on the poorly drained areas of the Precambrian Shield. It probably occupies about 35 % of the total area of coniferous forest.

The remaining 20 % of the coniferous forest is occupied by the pine forest, dominated in the Boreal zone by *Pinus banksiana*, in the Rocky Mountains by *P. contorta* var. *latifolia*. The pine forests occupy the light, sandy soils as well as areas of stony loam soils, that are common in the Cypress Hills and on the eastern slopes of the Rocky Mountains.

The climate of the Boreal forest zone does not differ much of that prevailing in the Parklands, or even that of most parts of the Prairie zone, except for a gradually lower average daily temperature with increasing latitude. Precipitation is in the 300–360 mm range over most of the area, but varies widely from year to year. In the southeastern part of Manitoba precipitation increases to 500 to 550 mm, and in most of the Rocky Mountains it may reach more than 550 mm.

More important than either temperature or precipitation alone are probably three other phenomena. One is the length of the winter season, or alternatively the short summer, which, combined with the relatively low summer temperatures with low evaporation, results in a fairly high precipitation efficiency. The second phenomenon is the high ratio of summer/spring precipitation, with summer precipitation about 1.3-x that of the spring season (LOOMAN 1983), which adds to the precipitation efficiency.

Below freezing temperatures occur in 7 or 8 months, and most of the precipitation during these months falls in the form of snow. This results in the third phenomenon: in favourable years with average or above average snowfall the accumulated snow may still be intact at the onset of spring, and remnants of large drifts in dense woods may still be present in mid-June or early July.

Together, these phenomena result in a climate that is, in comparison with that in areas of the Prairie Provinces with equal amounts of precipitation, considerably more humid. This is evident in the climatic index for the Boreal forest zone (LOOMAN 1979).

## Study methods

The classification presented here is based on relevés made in a total of 882 sites. In each site five plots, each measuring about 2500 $m^2$, were examined; species lists were made in each plot, and combined into a relevé. Tree height was estimated for the dominant trees, and cores were taken at breast hight in at least five of the largest trees. In all relevés the canopy cover of the diagnostic species was at least 60–80 %. Soil samples were taken for analysis in 120 sites; chemical analyses were done in the Soils Laboratory of the Canada Agriculture Research Station, Swift Current.

In addition to the relevés, more than 600 sites were examined. Most of these sites were either considered too small, or fragmentary, or time was insufficient to complete a "standard" relevé. These sites were not included in the association tables although in some instances the constancy of some of the kensorts was confirmed or diminished.

However, these "surveys" showed that in many areas deviating soil or topographic conditions caused variations in floristics, often characterized by the dominance of one or two species that usually are present, but only in small numbers of individuals. The species forming the "facies" are often vascular plants, but bryophytes can also become prominent, and occasionally exclude almost all vascular plants. The facies are rarely repeated with a very similar floristic composition, although only very few species form identifiable facies. Therefore, I have not attempted to describe the facies, but consider it sufficient to mention the existence of the more conspicuous forms.

## Results

### Classification

The Boreal forest zone was considered to be a "climatic climax" by WEAVER & CLEMENTS (1938), and was classified as the Spruce-Larch forest, the *Picea-Larix* formation. The formation was divided into the *Picea-Larix* and the *Picea-Pinus* associations, with the *Betula-Populus* associes as the "characteristic fire subclimax" throughout the entire Boreal forest. The Boreal forest climax occupied all of the North American continent between the grassland and deciduous forest climaxes in the south, and the tundra climax in the north.

Within the Boreal forest climax WEAVER & CLEMENTS (1938) described the Spruce-Larch association as eastern, reaching from the Atlantic coast to the Rocky Mountains. Its dominants were considered to be the white spruce and the balsam fir, *Abies balsamea*. The larch or tamarack, *Larix laricina*, was described as a climax species under more rigorous conditions, together with *Picea mariana*.

The coniferous forests of the North American mountain ranges were described as the Subalpine Forest, the *Picea-Abies* formation. In the Rocky Mountains of Alberta the Petran subalpine forests, or *Picea-Abies* association, with the *Pinus* consocies, were considered to occur at altitudes between about 950 m and 2200 m (WEAVER & CLEMENTS 1938). The major dominants in these forests were *Picea engelmannii* (= *P. glauca* var. *albertiana*) and *Abies lasiocarpa* (= *A. balsamea* var. *fallax*). Lodgepole pine, *Pinus contorta* var. *latifolia*, was considered to form the fire subclimax.

The classification of Canadian forests by HALLIDAY (1937) followed the system of WEAVER & CLEMENTS ". . . with some modifications and amendments arising from Canadian conditions." HALLIDAY used the term "Forest Region" rather than "formation" or "climax", and divided the Regions into "Forest Sections". These Sections are ". . . a geographical distinction based on broad uniformity of association, which is the result of topography, soil, bed-rock, and local climate."

The updating of HALLIDAY's work by ROWE (1959) used the same terms of

Forest Region and Forest Section, but with slightly different meanings. Thus, the Region "... corresponds to the concrete forest 'formation' as generally understood, but without the classical ecological implications. Particularly is the idea of a direct cause–effect relationship between present climate and Forest Regions ... disavowed." ROWE amended the term 'Forest Section', modifying its description to "... a geographic area possessing an individuality which is expressed relative to other Sections in a distinctive patterning of vegetation and of physiography." Forest Sections described by either HALLIDAY (1937) or ROWE (1959) can, therefore, include several different types of forest, each type dominated by one or more tree species. Despite the somewhat different interpretation of the terms "Region" and "Section", and the disavowal of the "climate-climax" relationship, ROWE's classification of the Canadian forests (1959) remained essentially the same as that devised by HALLIDAY (1937), and follows the "climatic climax" concept. Changes made by ROWE are refinements on HALLIDAY's work. Thus, in HALLIDAY's Boreal Forest Region B22, the Northern Coniferous Section covered much of northern Manitoba and northern Saskatchewan "... on the southern half of the Precambrian Shield ... where the soil cover is thin ...". However, areas with heavier soil desposits were included as a separate, but unnamed, Section. ROWE splits this Section off as B22b, the Athabasca South Section, leaving the Northern Coniferous Section as B22a.

Studies of the Boreal forest have not been as numerous as might be expected in view of their economic importance. Most of the studies made were more or less local (MOSS 1953; RITCHIE 1956, 1960a, b; PLOCHMANN 1956; VAN GROENEWOUD 1965a, b; SWAN & DIX 1966; JEGLUM 1973; ACHUFF & LAROI 1977, GRIFFITHS 1981, 1982; ACHUFF & CORNS 1982; PURCHASE & LAROI 1983). Only MOSS (1953) and ACHUFF & CORNS (1982) described "associations" and "vegetation types", respectively, based on several stands, and give a listing of the species with their frequency or abundance.

KNAPP's treatment of the North American coniferous forests (1965) was very brief indeed. He described these forests as the *Picea-Abies* forests (Fichten-Tannen-Wälder), in which several forms can be distinguished. Although the descriptions given by KNAPP are primarily based on eastern forests, some of the species are so widespread that the species lists provided by him apply at least to some extent to the Prairie Provinces. The same holds true for the Boreal Pine-forests (Boreale Sand-Kiefernwälder), which have a large number of species in common throughout the Boreal forest zone.

Classifications of Canadian coniferous forests outside the Prairie Provinces were described by DAMMAN (1964) and WALI & KRAJINA (1973). Both classifications were based on methods of the Zürich-Montpellier school, and arrived at descriptions of named associations.

DAMMAN (1964) described some of the forests in Newfoundland. The areas in which the forests studied were situated have a climate unlike that of either the Prairie Provinces or British Columbia. Precipitation averaged between 900 and 1000 mm, the average annual mean daily temperature 2.7–4.5 °C. The coniferous forests included those in which *Picea mariana* or *Abies balsamea* were dominant or at least important. Among these are some which are relevant to the Prairie Provinces: the Kalmia-conifer forests (K a l m i e t o - P i c e e t u m), the balsam

fir-white birch forests (Abietetum balsameae), the black spruce-moss forests (Piceetum marianae), and the alder-black spruce forest (Alneto-Piceetum). In a discussion of the problems encountered in classifying the Boreal forest vegetation DAMMAN mentioned the paucity of species and the prevailing soil conditions as causes of some of the difficulties. He noted that the thick layer of raw humus tends to level out any differences in soil factors, which then are reflected only weakly in the lesser vegetation.

The vegetation of sub-boreal white spruce forests in east-central British Columbia was studied by WALI & KRAJINA (1973). Although the area concerned is considerably lower than the Rocky Mountains, with altitudes of 640–820 m, the terrain is undulating, with many valleys and several lakes. The climate in the area is considerably warmer than that of either the Boreal forest zone, or the Rocky Mountain slopes. The average precipitation is reported as 660 mm. The forest vegetation, however, appears to be very similar to that of the Boreal forest zone, and many of the class and order kensorts are listed by WALI & KRAJINA (1973). The authors proposed a new order, which they named Piceetalia glaucae-marianae, divided into four alliances, six associations, and five subassociations and variants. Their classification was based on floristic groupings as well as environmental gradients.

The coniferous vegetation of both Newfoundland and British Columbia is, in many respects, very similar to that of the Prairie Provinces, and the classifications arrived at by DAMMAN (1964) and WALI & KRAJINA (1973) can be used as a basis for comparison with the vegetation, and hence, vegetation types, in our area. In particular, the diagnostic species groups (kengroups) used to characterize the associations, are of great interest, as many of the species occur throughout the Boreal forest zone, although it is possible that different kengroups are formed in different parts of the zone, and therefore different associations.

In the Prairie Provinces the problems encountered by DAMMAN (1964) in describing vegetation types, i.e., the paucity of species and leveling of soil differences, appear to be much less severe. The layer of raw humus in our coniferous forests is seldom very thick, except in the bog forests. In upland forest the layer is usually less than 5 cm thick; PURCHASE & LAROI (1983) found an average LFH horizon of 4 cm in their studies of pine forests in northern Alberta. In white spruce forest the LFH horizon is usually deeper, especially if the bryophyte layer is well developed. However, the layers are seldom thick enough to exclude all influence of the underlying mineral soil. As a result, the influence of the soil types – primarily derived from glacial tills, and including areas of aeolian sand – is usually still much reflected in the forest types. The herbaceous cover, especially, can retain elements of indicative value, as the several species common in pine forests on deep, infertile sand.

The forest described by WALI & KRAJINA (1973) also can have a rather thick layer of raw humus, but the differences in soil parent material are apparently much greater in British Columbia than in Newfoundland, with deep glacial deposits occurring in the major valleys. Moreover, the area in which these authors conducted their study is characterized by many hills and lakes, as well as numerous valleys, and erosion has played an important role. However, precipitation in their area is considerably less than in Newfoundland but is much higher in either

of these areas than in the Prairie Provinces, with the exception of the higher elevations in the Rocky Mountains.

The most important factor in the leveling of ecological factors in our area is probably the forest itself. Undisturbed forests exert a considerable influence on the prevailing climatic conditions as well as on soil water conditions. As has been mentioned, one important phenomenon is the fact that snow drifts can persist until late June or even early July. In addition, in some areas conditions resembling those approaching permafrost can be encountered.

However, the frequent forest fires (cf. LOOMAN 1987), in particular the so-called ground fires, can prevent the build-up of thick humus layers. Only in areas that have been spared for much longer than "normal" periods, moss and mull layers can be built up. KABZEMS et al. (1976) estimated that a given area in Saskatchewan's "Mixedwood Section" might be expected to burn every 300 years, given the frequency of fires observed over a period of 30 years. However, in the past decade the average annual number of forest fires in the Boreal forest zone of the Prairie Provinces has far exceeded the average for the period used by KABZEMS et al. The extension of roads into the northern areas to service newly established mines, and building of numerous campsites, in conjunction with very dry spring periods, contributed to this increase.

The paucity of species noted by DAMMAN (1964), is on an average much less pronounced in the Prairie Provinces than in Newfoundland, but depends to a large extent on soil characteristics. Thus, in my relevés both the highest and lowest number of vascular species in a stand occur in pine forest. Stands on dry, infertile sand have few vascular plant species, ranging from a low of 11 to a high of 18 species. The species diversity of mosses, lichens, and mushrooms in these stands is also low. Species diversity always increases with higher soil fertility and more favourable moisture conditions, reaching a high of 35 species in old stands on sandy soils with good moisture conditions, and average fertility. The diversity of mosses, lichens, and mushrooms also increases, along with their abundance and ground cover, which may reach 100 % in favourable circumstances. This is very similar to the situation in British Columbia. Thus, the lodgepole pine forests described by WALI & KRAJINA (1973) averaged 12 vascular plant species on the driest habitats, and 18 species on the somewhat wetter sites.

White and black spruce forests usually have fewer species than pine forest on fertile sands, and average about 25 species of vascular plants. Old white spruce forests on soils with good moisture conditions, and with trees of 200–250 years of age, tend to have a closed, thick, wet carpet of bryophytes, but few vascular plants. Occasionally, areas of a few hundreds of $m^2$ can be found in which the bryophyte cover virtually excludes all herbs, and only a few shrubs or subshrubs form a sparse layer.

However, the generally better moisture conditions in the Rocky Mountains and ranges of high altitudes exert a considerable influence on the species diversity. Consequently, spruce forests in the areas at higher altitudes are generally much richer in species than those in the Boreal forest zone, and may reach 35–40 species of vascular plants. For example, ACHUFF & LAROI (1977) found a considerable range of species diversity in their study, with the lowest species diversity bout 25, and the highest about 42 vascular species. GRIFFITHS (1981, 1982)

also, found high species diversity in (sub-)alpine forests in more southern parts of the Rocky Mountains. Diversity of the lichen and bryophyte layers did not vary as much as that of the vascular plants.

In the white spruce forests studied by VAN GROENEWOUD (1965b), species diversity also varied considerably, with some stands having fewer than 10 species, others as many as 40. Although species diversity was not necessarily related to growth characters of the white spruce, the highest diversity occurred on soils of intermediate texture and fertility (VAN GROENEWOUD 1965a). Though he differentiated three white spruce community types, no classification of these types was proposed, and the types were not named.

Although black spruce forest always has a continuous bryophyte cover, usually dominated by *Sphagnum*, vascular plants are never reduced to the same extent as that which may occur in white spruce forest. Almost always several ericaceous shrubs are present, as well as some sedges and other herbs. Occasionally, several species of orchids may be found, some of which are very rare.

The close affinities of the boreal forests throughout North America is evident from all descriptions. Comparison of these forests with those of the Boreal forest zones of Eurasia, as described by WALTER (1974), shows strong circumpolar affinities as well. Although the trees are represented by vicariant species, many of the low shrubs, herbs and mosses are identical or represented by varieties of the same species.

This affinity of the North American and Eurasian coniferous forest was already recognized by BRAUN-BLANQUET et al. (1939) in their classification of the North American coniferous forests with their Eurasian counterparts, in one order: Vaccinio-Piceetalia Br.-Bl. 1939. However, because *Vaccinium* spp. are abundant only in the pine forests and become less constant and less abundant in the white spruce forests, a new order, Pino-Piceetalia, is proposed for the coniferous forests of the Prairie Provinces. Three alliances can be recognized in this order, describing the forest types encountered in our area.

The classification of all associations is based on my own relevés, but several of the subassociations are in part based on the work of investigators in the areas where the associations are most widely distributed, and where I was not able to spend the time needed to collect large numbers of relevés. This is especially true for the Rocky Mountains and northwestern Alberta, where the number of relevés collected did not sufficiently reflect all vegetation types present. The associations and subassociations in the montane-subalpine areas were described with the use of several publications and reports (ACHUFF & CORNS 1982; HOLLAND & COEN 1982, 1983; HOLROYD & VAN TIGHEM 1983; ACHUFF & LAROI 1977; LAROI & HNATIUK 1980; PURCHASE & LAROI 1983; GRIFFITHS 1981, 1982).

It is possible to distinguish a large number of variants within each of the subassociations, based on differential species that occur as indicators of specialized ecological conditions, e.g., at high altitude or latitude. Thus, ACHUFF & CORNS (1982) recognized 37 vegetation types of "closed forest" in the Banff and Jasper National Parks, based on the prevalence or dominance of species in the shrub, herb or bryophyte layers of 20 x 20 m quadrats. In addition, an equally large number of vegetation types is recognized in the "open forest". The total area of these Parks, about 18 000 km$^2$, is only a fraction of the total coniferous forest

area. Most of these vegetation types are based on dominance of one or two shrubs, herbs, or mosses in the cover and are comparable to facies or variants.

However, many of the vegetation types recognized by ACHUFF & CORNS occupy only small areas, often only part of or not much more than the area of the 400 $m^2$. Thus, a *Picea glauca* dominated forest, occupying 10 $km^2$, may consist of two or more subassociations, each with numerous vegetation types in the sense of ACHUFF & CORNS. Although these small "units" may of interest or importance from a forestry standpoint, it seems futile to attempt a classification of these units in a hierarchy, where they would occur in most of the larger units.

**Synopsis of coniferous forests**

Class Vaccinio-Piceetea Br.-Bl. 1939
- Order Pino-Piceetalia ordo nova
  - Alliance Vaccinio-Pinion divaricatae all. nov.
    - Association Oryzopsio-Pinetum banksianae ass. nov.
      - vaccinietosum subass. nov.
      - piceetosum glaucae subass. nov.
      - piceetosum marianae subass. nov.
      - pinetosum resinosae subass. nov.
      - alnetosum subass. nov.
      - cladonietosum subass. nov.
    - Association Vaccinio-Pinetum contortae ass. nov.
      - vaccinietosum subass. nov.
      - spiraeetosum subass. nov.
      - calamagrostietosum subass. nov.
      - hedysaretosum subass. nov.
      - menziesietosum subass. nov.
      - pseudotsugetosum subass. nov.
      - piceetosum albertianae subass. nov.
      - pinetosum albicaulis subass. nov.
  - Alliance Piceo marianae-Laricion laricinae all. nov.
    - Association Ledo-Piceetum marianae ass. nov.
      - typicum variant
      - *Arceuthobium* variant
    - Association Piceo marianae-Laricetum laricinae ass. nov.
      - pinetosum divaricatae subass. nov.
    - Association Betulo-Piceetum marianae ass. nov.
    - Association Kalmio-Piceetum marianae ass. nov.
  - Alliance Piceon glaucae all. nov.
    - Association Vaccinio-Piceetum glaucae ass. nov.
      - typicum
      - abietetosum balsameae subass. nov.
      - pinetosum divaricatae subass. nov.
        - *Pinus banksiana* variant
        - *Pinus contorta* variant
      - piceetosum marianae subass. nov.

equisetetosum subass. nov.
thujetosum occidentalis subass. nov.
Association Piceetum albertianae ass. nov.
typicum
abietetosum lasiocarpae subass. nov.
pinetosum contortae subass. nov.
pinetosum albicauli subass. nov.
pseudotsugetosum subass. nov.
vaccinietosum subass. nov.

**Order Pino-Piceetalia**

The order and class are characterized by a kengroup of several species that occur in all parts of the Boreal forest zone. In the Prairie Provinces most of the species of this kengroup are surprisingly constant, with 60–80+ %[1] presence in several associations or alliances, although their abundance in the various associations can differ considerably. Several other species are more or less strongly associated with the kengroup, but are much less widespread. Several other species are limited to certain regions or soil types, e.g., southeastern Manitoba, western Canada, or sandy soils.

The following species form the kengroups of the order and class in the Prairie Provinces:

Cornus canadensis L.
Galium triflorum Michx.
Epilobium angustifolium L.
Trientalis borealis L.
Pyrola asarifolia Michx.
Pyrola secunda L.
Pyrola virens Schweigg.
Mitella nuda L.
Cornus alba L. var. stolonifera (Michx.) Boiv.
Arctostaphylos uva-ursi (L.) Spreng.
Linnaea borealis L. var. americana (Forbes) Rehder
Maianthemum canadense Desf. var. interius Fernald
Rubus idaeus L. var. aculeatissimus Regel & Tiling
Vaccinium vitis-idaea L. var. minus Lodd
Vaccinium angustifolium Ait. var. myrtilloides (Michx.) House

The kengroups have several species, or varieties of species, in common with the Pino-Piceetalia as characterized in Eurasia (WALTER 1974), although the degree of constancy of several species differs from that given by WALTER. Some of the species of the kengroup also occur in certain types of deciduous forest (LOOMAN 1987), although usually with less abundance.

[1] + means: "or more", "and over"

### Alliance Vaccinio-Pinion divaricatae

The pine forests of the Boreal forest zone, together with those of the forested ranges of hills and the Rocky Mountains, can be grouped in one alliance, consisting of two associations. The name derives from *Pinus divaricata* (Ait.) Dumont, the collective name for the two "small" species, *P. banksiana* (= *P. divaricata* var. *divaricata*), and *P. contorta* var. *latifolia* (= *P. divaricata* var. *latifolia*).

The pine forests are usually considered to be a fire subclimax, replacing the climax white spruce after fires or clear-cutting, especially on sandy soils. However, the often expressed idea that fire is necessary for the opening up of pine cones (cf. CURTIS 1959), and release of seed is erroneous. Pine cones ripen and begin to release seed in the fourth or fifth year when the resins holding the cones closed have weathered. In addition, squirrels and cross bills tend to spread numerous seeds while feeding on the pines. Consequently, natural regeneration of pines without fire can occur wherever conditions are suitable for germination of the seeds, and establishment and survival of the seedlings.

Pines are short lived. The trees reach maturity at 70–80 years of age, and begin to decline, and start dying off, at about 100 years. If the openings created by the death of trees are large and open enough to allow for the light conditions required for the germination of pine seeds, the seedlings can establish, and eventually stands can be rejuvenated. In most stands seedlings are a rather rare occurrence, as under most of the natural conditions prevailing white spruce can replace the pines.

The difference between the two associations, besides the fact that two varieties of one species of pine are involved, is primarily geographic. The lodgepole pine, *Pinus contorta*, is montane-alpine, while the jack pine, *P. banksiana*, is boreal. The two pines meet in northwestern Alberta, where the boreal forest and the forests of the Rocky Mountains meet. Intermediates between the two pines occur in several areas. A corollary of the geographic distribution of the two pines is a difference in predominance of soil types of the habitat. The soils in the Cypress Hills and the Rocky Mountains are predominantly of pre-glacial origin, and sands are relatively rare while stoniness is very common. Most of the hills, in particular the ridges and crests, have been subject to usually severe erosion, which left only a shallow layer of soil overlying an often deep bed of pebbles.

Despite the difference in soil textures, the main characteristic, soil fertility, is very similar throughout the stands in the alliance. Thus, the average pH in 42 relevés is 4.8 ± 0.6, with a range of pH 4.0–6.2 in the upper 5–7 cm of soil, with very low amounts of P, Ca, and Mg, and N often not detectable. This is in agreement with the findings of KABZEMS & KIRBY (1956). However, PURCHASE & LAROI (1983) found pH 6.1–7.7 in their samples, with P often in amounts usually considered as sufficient. They do not indicate values for Ca and Mg; their values for K are similar to those in my samples, but this element is rarely low or deficient in the Prairie Provinces.

The absence of high pH values in my own soil samples may be due to the fact that no soil samples were taken in the forests of north-central Alberta, where PURCHASE & LAROI conducted their studies. Two of my soil samples taken in the area of Fort Smith, N.W.T., northeast of Fort Vermilion, had pH 6.6 and 7.2.

Soils in this area have a tendency towards salinity, a condition which may well be general along the Peace River near Fort Vermilion, thus accounting for the high pH values found by PURCHASE & LAROI.

Trees in 42 of my own relevés in which soil samples were taken ranged in age from 28 to 80 years, averaging 49.5 ± 5.7 years of age. Height of the trees ranged from 15 to 22 m, the diameters from 105 to 360 mm, with an average of 184 mm, and an annual increment in diameter of 3.7 ± 0.38 mm (Photo 1). About equal numbers of trees of both varieties were measured, and no significant varietal differences were noted. However, trees in the southern parts of the regions tended to show somewhat better growth than those in the more northern, and therefore colder and drier, zones.

The growth rate (in diameter) of trees was found to be faster in young trees than in the older ones, averaging 4.8 mm/year in trees younger than 45 years, compared with 3.6 mm/year in trees of 45–80 years old. The total number of trees measured was too small to further subdivide the age classes, or to take into account the influence of soil fertility or soil moisture conditions. KABZEMS & KIRBY (1956) indirectly showed the influence of soil fertility on the growth of pines by calculating "future 10-year diameter increments", based on the present age and diameter of the trees. Their figures showed that a 20 year old tree could be expected to increase an average of 6.6 mm/year if the present diameter was 125 mm, but 8.2 mm/year if the diameter was 150 mm. For a 60 year old tree

**Photo 1. Many pines are affected by the parasite *Arceuthobium americanum* and show the typical witches broom.**

the expected increments would be 1.1 and 1.4 mm/year, respectively, showing the influence of the soil fertility level on tree growth. The decreasing growth rate with increasing age was indicated by projecting future increments through several decades. Thus, projecting the growth rate of a 20 year old tree with a present diameter of 125 mm, the increments in the next four decades would be 66 mm, 56 mm, 47 mm and 42 mm. However, a succession of unfavourable years, e.g., a prolonged drought in a given decade, could greatly reduce the size of the increment during that decade. On the other hand, a succession of several favourable years would increase the size of the increment and could mask the effect of reduced growth as a result of ageing.

### Association Oryzopsio-Pinetum banksianae

The pine forests of the Boreal forest zone throughout the three Prairie Provinces belong to this association (Table 1). It extends eastward into Ontario, and to the west into British Columbia. Much of the coniferous forests of the North West Territories, Yukon, and Alaska on light and sandy soils may also belong to this association. The parasite *Arceuthobium americanum*, causing "witches brooms" (Photo 1), is fairly common on both *Pinus banksiana* in the Boreal forest zone and on *P. contorta* in the mountain forests. The species occasionally attacks large areas of young pines established after a fire, killing many of the trees and retarding their growth. Its distribution in western Canada was discussed by KUIJT (1963). In turn, *Walrothiella arceuthobii* may be found parasitizing female plants of *Arceuthobium*.

Well stocked sites have a density of about 1000 trees/ha, with *Pinus* contributing 75–80 % of this number. Canopy cover in such stands is close to 100 %, but usually allows for a shrub and herb layer with 30–40 % cover. Under favourable moisture conditions a considerable number of species of mushrooms can be found in pine forest. In several stands I have noted as many as 16–20 different species, with *Lactarius*, *Boletus* and *Russula* common.

The subassociation v a c c i n i e t o s u m may well be considered to be the distinctive form of the association, and usually represents the "climax", but in the sense of "Dauergesellschaft". Most of the forest in this subassociation is more than 100 years old. The herbaceous cover varies greatly, but is usually at least 30 %. Bryophytes and lichens are equally variable, ranging from sparse to about 30 %, and is usually localized.

Burned-over pine forest may require several years to return to a state of recovery. If the arboreal, shrub, and herbaceous cover all have been affected, several species may invade from the surrounding vegetation, and form an open cover that may persist for some years. In northern Manitoba an area of v a c c i n i e t o s u m forest, at least 30 km long and more than 20 km wide, was burned in 1978. In 1981 the groundcover in most of this burn was about 50 %, and consisted of only five species: *Elymus innovatus*, with about half of the cover; *Agrostis scabra*, *Gaillardia aristata*, *Achillea millefolium*, and *Helianthus annuus* sharing the remainder in various proportions (Photo 2). Pine seedlings and shrubs were absent in all of the areas examined.

**Table 1.** Association table of Oryzopsio-Pinetum banksianae.

| Subassociation | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Number of relevés | 60 | 42 | 47 | 21 | 43 | 36 |
| **1. Subass. vaccinietosum** | | | | | | |
| D Vaccinium angustifolium myrtilloides | **V.3** | II.+ | IV.2 | V.1 | II.+ | III.2 |
| D Vaccinium caespitosum | **V.2** | I.+ | IV.1 | IV.2 | II.+ | I.+ |
| **2. Subass. cladonietosum** | | | | | | |
| D Oryzopsis pungens | III.1 | **V.2** | I.+ | - | - | - |
| D Festuca ovina saximontana | II.+ | **V.1** | - | - | - | - |
| D Lycopodium sabinifolium | - | **III.1** | - | - | - | - |
| D Cladonietum* | II.1 | **V.3** | I.+ | III.1 | - | II.1 |
| **3. Subass. piceetosum glaucae** | | | | | | |
| D Picea glauca | V.1 | I.+ | **V.3** | II.+ | III.1 | II.+ |
| **4. Subass. pinetosum resinosae** | | | | | | |
| D Pinus resinosa | I.+ | - | - | **V.2** | - | - |
| D Ceanothus ovalis | - | - | - | **III.1** | - | - |
| D Diervilla lonicera | - | - | - | **III.1** | - | - |
| D Lechea stricta | - | - | - | **III.+** | - | - |
| **5. Subass. alnetosum** | | | | | | |
| D Alnus viridis sinuata | I.+ | - | I.+ | I.+ | **V.3** | II.1 |
| D Lycopodium annotinum | II | III | III | I | **V** | - |
| **6. Subass. piceetosum marianae** | | | | | | |
| D Picea mariana | - | - | - | - | II.1 | **V.2** |
| D Chamaedaphne calyculata | - | - | - | - | - | **IV.1** |
| D Ledum palustre | I.+ | - | - | - | II.+ | **III.1** |
| D Oxycoccus palustris | - | - | - | - | - | **IV.+** |
| D Carex gynocrates | - | - | - | - | - | **III.+** |
| D Carex capitata | - | - | - | - | - | **III.+** |
| D Sphagnetum** | - | - | - | - | - | **V.1** |
| Association **ORYZOPSIO-PINETUM BANKSIANAE** | | | | | | |
| K Pinus banksiana | **V.4** | **V.4** | **V.4** | **V.4** | **V.4** | **V.4** |
| K Melampyrum lineare | **III.+** | **V.1** | **IV.+** | **IV.+** | **III.+** | **III.+** |
| Alliance **VACCINIO-PINION DIVARICATAE** | | | | | | |
| K Elymus innovatus | V.1 | V.1 | V.+ | IV.1 | V.+ | III.+ |
| K Oryzopsis asperifolia | V.1 | V.1 | V.1 | V.+ | III.+ | IV.+ |
| K Spiraea alba | IV.1 | IV.1 | III.1 | V.1 | III.1 | III.+ |
| K Apocynum androsaemifolium | III | III | II | II | I | I |
| K Arceuthobium americanum | II | III | II | II | I | I |
| **Order and Class** | | | | | | |
| O Cornus canadensis | V | II | V | III | V | V |
| O Pyrola asarifolia | III | II | IV | IV | III | IV |
| O Maianthemum canadense | V | I | V | IV | V | V |
| O Mitella nuda | I | - | II | II | II | II |
| O Trientalis borealis | II | I | III | II | III | IV |
| O Pyrola virens | II | I | III | III | III | II |
| C Arctostaphylos uva-ursi | V.2 | V.1 | V.2 | IV.1 | II.1 | III.1 |
| C Cornus alba stolonifera | V.+ | I.+ | V.+ | IV.+ | II.+ | III.+ |
| C Rubus idaeus aculeatissimus | IV.1 | II.+ | V.1 | III.1 | IV.1 | III.1 |
| C Vaccinium vitis-idaea | III.1 | I.+ | III.1 | III.+ | III.1 | IV.1 |
| C Pyrola secunda | IV | III | III | IV | IV | III |
| C Epilobium angustifolium | IV | II | IV | III | II | III |
| C Linnaea borealis americana | III | II | V | III | V | V |
| C Galium triflorum | II | I | III | III | III | III |
| C Pleurozium community# | V.2 | V.1 | V.3 | V.2 | V.3 | I.+ |
| Accompanying species: | | | | | | |
| Populus tremuloides | V.1 | I.+ | IV.1 | I.+ | IV.1 | III.+ |
| Populus balsamifera | V.1 | - | V.1 | - | III.1 | II.1 |
| Betula papyrifera | III.1 | I.+ | III.1 | III.+ | II.1 | V.1 |
| Abies balsamea | - | - | I.+ | I.+ | - | - |
| Larix laricina | - | - | - | - | - | II.+ |
| Shepherdia canadensis | V.2 | II.+ | V.2 | III.1 | II.1 | III.1 |
| Rosa acicularis | V.+ | V.+ | V.+ | V.+ | V.+ | V.+ |
| Viburnum edule | III.+ | I.+ | III.+ | III.+ | I.+ | IV.1 |
| Juniperus communis | III.+ | III.+ | II.+ | III.+ | II.+ | I.+ |
| Juniperus horizontalis | II.+ | III.+ | I.+ | II.+ | - | I.+ |
| Salix bebbiana | IV.1 | I.+ | III.+ | I.+ | III.+ | III.+ |
| Lonicera involucrata | IV.1 | I.+ | III.1 | III.1 | I.+ | I.+ |
| Amelanchier alnifolia | II.+ | III.+ | II.+ | II.+ | III.1 | I.+ |
| Prunus virginiana | II.+ | II.+ | II.+ | II.+ | II.+ | - |
| Ribes oxyacanthoides | I.+ | - | I.+ | I.+ | II.+ | II.+ |
| Ribes americanus | II.+ | - | III.+ | II.+ | II.+ | - |
| Prunus pensylvanica | II.+ | - | II.+ | I.+ | I.+ | - |
| Rubus pubescens | II.+ | - | II.+ | - | - | III.+ |
| Lonicera oblongifolia | I.+ | - | II.+ | II.+ | - | - |
| Prunus pumila | I.+ | III.+ | - | II.+ | - | - |
| Ledum palustre | - | - | I.+ | - | II.+ | III.1 |

Table 1. cont.

| Subassociation<br>Number of relevés | 1<br>60 | 2<br>42 | 3<br>47 | 4<br>21 | 5<br>43 | 6<br>36 |
|---|---|---|---|---|---|---|
| Salix monticola | I.+ | - | I.+ | - | I.+ | - |
| Betula glandulifera | - | - | - | - | II.+ | II.+ |
| Ribes lacustre | - | - | - | - | II.+ | II.+ |
| Salix glauca | - | - | - | - | I.+ | II.+ |
| Potentilla fruticosa floribunda | - | - | - | I.+ | - | II.+ |
| Parthenocissus quinquefolia | - | - | - | II.+ | - | - |
| Rhus glabra | - | - | - | II.+ | - | - |
| Salix myrtillifolia | - | - | - | - | - | III.1 |
| Salix pedicellaris | - | - | - | - | - | III.+ |
| Schizachne purpurascens | IV | II | V | V | III | IV |
| Poa nemoralis | - | - | I | I | I | I |
| Calamagrostis rubescens | I | - | I | - | II | - |
| Cinna latifolia | - | - | I | I | - | - |
| Poa compressa | II | II | - | - | - | - |
| Carex concinnoides | II | II | I | - | - | - |
| Carex siccata | II | IV | - | - | - | - |
| Calamagrostis canadensis | - | - | - | - | II | III |
| Calamagrostis inexpansa | - | - | - | - | I | II |
| Carex magellanica | - | - | - | - | - | III |
| Eriophorum vaginatum spissum | - | - | - | - | - | II |
| Equisetum scirpoides | II | II | III | II | II | III |
| Equisetum sylvaticum | I | - | II | - | II | I |
| Lycopodium complanatum | I | III | I | III | III | II |
| Lycopodium obscurum | I | - | II | - | - | I |
| Lycopodium clavatum | - | - | I | - | - | II |
| Fragaria virginiana | II | I | I | III | III | III |
| Aralia nudicaulis | III | I | III | III | I | II |
| Hedysarum alpinum americanum | III | II | II | II | I | I |
| Hieracium umbellatum | III | II | III | II | II | II |
| Geocaulon lividum | V | III | III | II | II | I |
| Mertensia paniculata | III | I | III | II | III | II |
| Chimaphila umbellata | II | II | II | II | I | - |
| Petasites palmatus | II | I | II | II | II | - |
| Vicia americana | II | - | II | I | I | II |
| Aster ciliolaris | II | I | II | - | II | - |
| Aster laevis | II | I | III | - | II | - |
| Empetrum nigrum | I | I | - | - | I | III |
| Galium boreale | II | III | II | II | - | - |
| Goodyera repens | I | - | II | I | III | I |
| Lathyrus ochroleucus | I | I | - | - | II | II |
| Moneses uniflora | I | - | I | - | I | I |
| Anemone patens wolfgangiana | II | II | I | - | - | - |
| Antennaria howellii | II | - | II | III | - | - |
| Arabis lyrata | III | V | II | - | - | - |
| Aster conspicuus | II | - | III | - | I | - |
| Corallorhiza striata | I | - | I | - | II | - |
| Monotropa hypopitis | II | - | II | I | - | - |
| Potentilla tridentata | III | IV | I | - | - | - |
| Pyrola rotundifolia | II | - | II | - | I | - |
| Trientalis borealis | - | - | I | - | II | II |
| Arnica cordifolia | II | - | II | - | - | - |
| Calypso bulbosa | I | - | II | - | - | - |
| Coptis trifolia | I | - | II | - | - | - |
| Corallorhiza maculata | II | - | II | - | - | - |
| Corallorhiza trifida | II | - | II | - | - | - |
| Cypripedium acaulum | II | - | I | - | - | - |
| Goodyera oblongifolia | - | - | II | II | - | - |
| Habenaria hyperborea | - | - | - | - | II | II |
| Hudsonia tomentosa | II | III | - | - | - | - |
| Osmorhiza chilensis | I | - | II | - | - | - |
| Physalis grandiflora | II | III | - | - | - | - |
| Smilacina stellata | I | - | II | - | - | - |
| Antennaria plantaginifolia | - | - | - | III | - | - |
| Aster umbellatus | - | - | - | II | - | - |
| Clintonia borealis | - | - | - | II | - | - |
| Epigaea repens | - | - | - | II | - | - |
| Gaultheria procumbens | - | - | - | II | - | - |
| Lechea media | - | - | - | II | - | - |
| Parnassia palustris | - | - | - | - | - | II |
| Sarracenia purpurea | - | - | - | - | - | II |
| Smilacina bifolia | - | - | - | - | - | II |

Table 1. cont.

* Cladonietum: a mixture of Cladonietum multiformis Loom. 1962 and C. alpestris Loom. 1962, with Cladonia multiformis, C. gracilis, C. amaurocraea, C. cenotea, C. coccifera, C. deformis, C. verticillaris, C. coccifera, C. cornutoradiata, C. cristatella, C. pleurota, C. mitis, C. fimbriata, C. uncialis, C. rangiferina, C. sylvatica, C. alpestris; Cetraria nivalis, C. islandica; Stereocaulon tomentosum; Peltigera canina, P. aphthosa, P. rufescens; Psoroma hypnorum.

** Sphagnetum includes: Sphagnum angustifolium, S. fuscum, S. warnstorfianum; Tomenthypnum nitens; Aulacomnium palustre; Icmadophilum ericetorum.

# Pleurozium community includes: Brachythecium starkei; Dicranum polysetum, D. scoparium, D. undulatum; Drepanocladus aduncus, D. revolvens, D. uncinatus; Hylocomium splendens; Pleurozium schreberi; Pohlia nutans; Polytrichum juniperinum, P. commune, P. norvegicum; Ptilium crista-castrensis; Pylaisia polyantha; Thuidium abietinum; Tortula ruralis; Blepharostoma trichophyllum; Lophozia lycopodioides; Ptilidium ciliare, P. pulcherrinum.

The c l a d o n i e t o s u m is at the driest end of the soil moisture scale. It occurs on the driest soils, although several degrees of dryness can be distinguished, each characterized by one or more species of lichens (cf. OKSANEN & AHTI 1982). The driest stands usually have abundant *Cladonia multiformis* or *C. mitis*, the relatively wettest sites have a predominance of *C. rangiferina* or *C. alpestris*.

The p i c e e t o s u m g l a u c a e occurs primarily on soils of somewhat heavier texture than that on which the v a c c i n i e t o s u m is found. Most of the soils are sandy loam, but occasionally stands occur on stony loam. It seems likely that *Picea glauca* will eventually replace the pine forest, with succession to the p i n e t o s u m b a n k s i a n a e subassociation of the V a c c i n i o - P i c e e t u m g l a u c a e an intermediate stage. The cover of bryophytes is

**Photo 2. Several species settling in burned-over forest are derived from roadsides or nearby open areas, and form an open cover that may persist for several years.**

commonly in excess of 30 %, and locally can reach 90 %. Lichens are mostly sparse, and localized.

The pinetosum resinosae is limited to the extreme southeastern part of Manitoba, and is an extension of the more southern forest vegetation types of the northern United States, where *Pinus resinosa* is an important part of forest associations, e.g., the "northern dry forest" of Minnesota and Wisconsin (CURTIS 1959). The species is much less common, and much less prevalent, in our area. Most of the stands are on dry sand and the lichen cover is well developed, often reaching 60 %, with the dry forms of the "Cladonietum" (cf. Table 1 footnote) predominant. Bryophytes are sparse, with low cover of mostly *Pleurozium schreberi*.

The alnetosum, characterized by the abundance, and often predominance, of *Alnus viridis* ssp. *sinuata* in the shrub layer, occurs on soils with a relatively high water table. Small areas, or fragments, occur in many areas where sand deposits vary greatly in depth, but stands are best developed in relatively large areas of several hectares. The bryophyte cover reflects the favourable moisture conditions, with cover often in excess of 80 %, and an abundance of *Drepanocladus uncinatus* and *Ptilium crista-castrensis*.

The piceetosum marianae is common in areas where muskeg developed on wet sandy soils. The shrub cover is often dense and commonly dominated by *Ledum palustre* or *Chamaedaphne calyculata*. The moss cover consists of "Sphagnetum" (cf. Table 1 footnote) with much admixture of acrocarpous mosses, primarily *Polytrichum* spp. The lichen cover is often dominated by *Cladonia alpestris*, and *Icmadophila ericetorum* is usually well represented by several large thalli.

### Association Vaccinio-Pinetum contortae

The forests of the Cypress Hills in southwestern Saskatchewan and southeastern Alberta, the eastern slopes of the Rocky Mountains in Alberta, and some hilly areas in northwestern Alberta on light sandy or stony soils, belong to this association (Table 2). Considerable areas of these forests are used as cattle range, and the shrubby as well as the herbaceous cover become depleted, and are replaced by unpalatable grasses. Logged-over areas are often left to become naturally reforested, and often become dominated by grasses. In a few areas pure or almost pure stands of pine occur, with little or no shrub and herb cover, but with an almost closed carpet of *Pleurozium schreberi* covering several hundreds of $m^2$. The cause of this paucity in species, and high moss cover could not be ascertained.

As in the Oryzopsio-Pinetum banksianae, the vaccinietosum may be considered to be the distinctive subassociation. Following ACHUFF & CORNS (1982), two variants of this subassociation can be distinguished, according to the dominant species of *Vaccinium* involved. The more common of the two forms is that in which *V. caespitosum* dominates the low shrub layer; less common is the form with *V. scoparium*. However, occasionally stands are encountered in which *Vaccinium* is represented by all of the common species: *angustifolium*, *caespitosum*, *scoparium*, and *vitis-idaea*. The bryophyte and lichen cover are usually sparse, reaching at most 30 %.

Table 2. Association table of Vaccinio-Pinetum contortae.

| Subassociation<br>Number of relevés | 1<br>28 | 2<br>22 | 3<br>22 | 4<br>24 | 5<br>20 | 6<br>18 | 7<br>32 | 8<br>17 |
|---|---|---|---|---|---|---|---|---|
| 1. Subassociation **vaccinietosum** | | | | | | | | |
| D Vaccinium angustifolium myrtilloides | **V.2** | III.1 | II.+ | IV.1 | II.+ | II.+ | IV.1 | II.+ |
| D Vaccinium caespitosum | **III.2** | II.+ | II.+ | - | - | - | - | - |
| D Vaccinium scoparium | **III.2** | - | - | III.1 | IV.1 | II.+ | III.1 | I.+ |
| 2. Subassociation **spiraeetosum** | | | | | | | | |
| D Spiraea lucida | II.+ | **V.1** | I.+ | I.+ | I.+ | - | - | - |
| 3. Subassociation **calamagrostietosum** | | | | | | | | |
| D Calamagrostis rubescens | - | I.+ | **V.2** | I.+ | I.+ | - | - | - |
| 4. Subassociation **hedysaretosum** | | | | | | | | |
| D Hedysarum sulphurescens | - | - | - | **V.1** | - | - | II.+ | - |
| D Hedysarum alpinum americanum | II.+ | I.+ | - | **IV.1** | - | - | II.+ | - |
| D Aquilegium flavescens | - | - | - | **IV.+** | - | - | II.+ | - |
| D Viola orbiculata | - | - | - | **III** | II | - | II | - |
| 5. Subassociation **menziesietosum** | | | | | | | | |
| D Menziesia ferruginea | - | - | - | - | **V.1** | - | I.+ | - |
| D Rhododendron albiflorum | - | - | - | - | **III.+** | - | I.+ | - |
| 6. Subassociation **pseudotsugetosum** | | | | | | | | |
| D Pseudotsuga menziesii | - | - | - | - | I.+ | **V.2** | I.+ | - |
| D Pinus flexilis | - | - | - | - | - | **III.1** | - | - |
| D Juniperus scopulorum | - | - | - | - | - | **V.1** | II.+ | II.+ |
| 7. Subassociation **piceetosum albertianae** | | | | | | | | |
| D Picea glauca albertiana | I.1 | - | - | II.+ | II.+ | I.+ | **V.3** | II.+ |
| 8. Subassociation **pinetosum albicaulis** | | | | | | | | |
| D Pinus albicaulis | - | - | - | I.+ | III.+ | - | - | **V.3** |
| D Festuca campestris | - | - | - | - | - | III | - | **IV.2** |
| D Aster sibiricus | - | - | - | - | - | II | - | **IV.+** |
| Association **VACCINIO-PINETUM CONTORTAE** | | | | | | | | |
| K Pinus contorta | **V.4** | **V.4** | **V.4** | **V.4** | **V.4** | **V.4** | **V.4** | **V.4** |
| K Antennaria racemosa | **III.+** | **III.+** | **III.+** | **IV.+** | **III.+** | **II.+** | **IV.+** | **I.+** |
| K Solidago multiradiata | **III** | **III** | **II** | **IV** | **IV** | **III** | **IV** | **II** |
| Alliance **VACCINIO-PINION DIVARICATAE** | | | | | | | | |
| K Elymus innovatus | V.1 | V.1 | V.1 | V.1 | V.1 | III.1 | V.1 | III.1 |
| K Oryzopsis asperifolia | V.1 | V.1 | III.+ | V.1 | III.+ | III.+ | V.1 | III.+ |
| K Apocynum androsaemifolium | II | II | II | III | III | I | III | II |
| K Arceuthobium americanum | I | I | - | II | - | I | I | - |
| **Order and Class** | | | | | | | | |
| O Cornus canadensis | V | V | III | V | III | III | V | II |
| O Pyrola asarifolia | V | V | V | V | II | II | V | - |
| O Pyrola virens | III | II | III | II | III | I | IV | - |
| O Maianthemum canadense | V | V | III | III | II | III | V | - |
| O Mitella nuda | III | III | II | - | II | - | III | - |
| C Arctostaphylos uva-ursi | V.1 | V.1 | IV.1 | V.1 | III.1 | II.+ | V.1 | I.+ |
| C Rubus idaeus aculeatissimus | III.1 | IV.1 | IV.1 | II.+ | I.+ | I.+ | IV.1 | I.+ |
| C Cornus alba stolonifera | II.+ | III.+ | II.+ | II.+ | I.+ | - | III.+ | - |
| C Vaccinium vitis-idaea | III.+ | II.+ | III.1 | II.+ | IV.1 | - | III.1 | - |
| C Pyrola secunda | V | V | V | V | V | V | V | I |
| C Linnaea borealis americana | V | V | IV | IV | III | II | V | II |
| C Epilobium angustifolium | III | III | III | I | III | II | II | III |
| C Galium triflorum | III | III | III | II | III | - | III | - |
| C Cladonietum* | IV.+ | III.+ | - | V.+ | II.+ | - | V.+ | - |
| C Pleurozium community** | V.+ | V.+ | IV.+ | V.1 | V.1 | II.+ | V.+ | - |
| Accompanying species: | | | | | | | | |
| Populus tremuloides | II.+ | IV.1 | III.+ | II.+ | II.+ | II.+ | III.+ | - |
| Populus balsamifera | II.+ | III.1 | III.+ | I.+ | III.+ | - | III.+ | - |
| Betula papyrifera | II.+ | - | - | I.+ | II.+ | - | II.+ | - |
| Abies lasiocarpa | I.+ | I.+ | I.+ | - | I.+ | - | II.+ | - |
| Larix lyallii | - | - | - | - | II.+ | - | I.+ | - |
| Shepherdia canadensis | V.1 | V.1 | IV.1 | V.1 | III.1 | II.+ | V.1 | I.+ |
| Rosa acicularis | V.+ | V.+ | III.+ | V.+ | II.+ | II.+ | IV.+ | II.+ |
| Juniperus communis | III.+ | III.+ | I.+ | IV.1 | III.1 | II.+ | III.1 | III.+ |
| Juniperus horizontalis | II.+ | II.+ | - | III.1 | I.+ | I.+ | II.+ | - |
| Salix bebbiana | III.+ | V.1 | III.1 | II.+ | II.+ | I.+ | III.+ | - |
| Viburnum edule | III.+ | III.+ | II.+ | II.+ | III.+ | II.+ | III.+ | - |
| Potentilla fruticosa floribunda | II.+ | II.+ | I.+ | I.+ | III.+ | - | II.+ | - |
| Alnus viridis sinuata | I.+ | I.+ | II.+ | - | II.+ | - | II.+ | - |
| Amelanchier alnifolia | II.+ | II.+ | II.+ | II.+ | - | - | II.+ | - |
| Lonicera involucrata | II.+ | II.+ | I.+ | II.+ | - | - | III.+ | - |
| Prunus virginiana | III.+ | III.+ | I.+ | II.+ | - | - | II.+ | - |
| Prunus pensylvanica | II.+ | II.+ | I.+ | - | - | - | II.+ | - |
| Salix monticola | II.+ | - | - | II.+ | - | - | II.+ | - |
| Ledum palustre | - | - | - | - | II.+ | - | I.+ | - |

Table 2. cont.

| Subassociation<br>Number of relevés | 1<br>28 | 2<br>22 | 3<br>22 | 4<br>24 | 5<br>20 | 6<br>18 | 7<br>32 | 8<br>17 |
|---|---|---|---|---|---|---|---|---|
| Ribes lacustre | - | - | - | - | II.+ | - | II.+ | - |
| Rubus pedatus | - | - | - | - | I.+ | - | II.+ | - |
| Betula glandulifera | - | - | - | - | III.+ | - | - | - |
| Salix glauca | - | - | - | - | II.+ | - | - | - |
| Salix myrtillifolia | - | - | - | - | II.+ | - | - | - |
| Rubus pubescens | - | - | - | - | - | - | II.+ | - |
| Festuca ovina saximontana | I | - | - | II | - | - | I | I |
| Poa nemoralis | I | I | - | I | - | - | I | - |
| Schizachne purpurascens | III | III | I | I | - | - | - | - |
| Bromus pumpellianus | - | - | - | II | - | - | III | II |
| Calamagrostis purpurascens | - | - | II | II | - | - | II | - |
| Cinna latifolia | - | II | II | - | - | - | II | - |
| Poa compressa | - | - | - | - | - | - | - | II |
| Carex concinna | II | II | - | II | - | I | II | - |
| Carex concinnoides | III | II | - | II | - | - | II | - |
| Carex siccata | - | - | - | III | - | - | II | II |
| Equisetum scirpoides | II | II | III | - | III | - | II | - |
| Equisetum sylvaticum | I | II | II | - | - | - | II | - |
| Lycopodium annotinum | II | I | - | - | - | - | III | - |
| Lycopodium complanatum | I | II | - | - | - | - | II | - |
| Lycopodium obscurum | - | - | - | - | - | - | II | - |
| Antennaria howellii | III | III | II | II | I | I | III | I |
| Fragaria virginiana | V | V | III | V | II | I | III | I |
| Aralia nudicaulis | II | II | I | II | I | - | II | - |
| Lathyrus ochroleucus | III | III | I | IV | I | - | II | - |
| Thalictrum occidentale | II | II | III | I | II | - | III | - |
| Vicia americana | III | III | II | II | I | - | II | - |
| Antennaria racemosa | II | II | I | II | - | - | II | - |
| Arnica cordifolia | III | III | II | II | - | - | III | - |
| Aster ciliolaris | II | II | - | II | I | - | III | - |
| Aster conspicuus | II | III | - | II | II | - | III | - |
| Aster laevis | II | II | I | II | - | - | II | - |
| Corallorhiza maculata | III | II | II | II | - | - | III | - |
| Galium boreale | II | II | - | II | - | - | I | II |
| Hieracium albiflorum | III | III | II | II | - | - | III | - |
| Mertensia paniculata | III | II | II | III | - | - | III | - |
| Osmorhiza chilensis | II | II | I | II | - | - | II | - |
| Castilleja miniata | II | II | - | III | - | - | III | - |
| Corallorhiza trifida | II | III | II | II | - | - | - | - |
| Goodyera repens | II | II | - | II | - | - | II | - |
| Smilacina racemosa | I | I | - | II | - | - | II | - |
| Petasites palmatus | II | II | I | - | - | - | II | - |
| Arnica latifolia | - | - | - | II | II | - | III | - |
| Aster subspicatus | - | - | - | I | I | - | II | - |
| Astragalus alpinus | - | - | - | II | II | - | II | - |
| Astragalus robbinsii | - | - | - | II | I | - | II | - |
| Empetrum nigrum | - | - | - | I | III | - | II | - |
| Pterospora andromedea | III | III | I | - | - | - | - | - |
| Smilacina stellata | II | I | - | I | - | - | - | - |
| Stenanthium occidentale | I | - | - | II | - | - | II | - |
| Pedicularis bracteosa | - | - | - | II | II | - | II | - |
| Valeriana sitchensis | - | - | - | I | II | - | II | - |
| Angelica dawsonii | - | - | - | - | III | - | II | - |
| Erythronium grandiflorum | - | - | - | - | II | - | II | - |
| Habenaria hyperborea | - | - | - | - | II | - | II | - |
| Trollius albiflorus | - | - | - | - | II | - | II | - |
| Veratrum eschscholtzii | - | - | - | - | II | - | II | - |
| Cassiope mertensiana | - | - | - | II | - | - | II | - |
| Cassiope tetragona | - | - | - | I | - | - | II | - |
| Geocaulon lividum | - | - | - | II | - | - | III | - |
| Listera cordata | - | - | - | I | - | - | II | - |
| Phyllodoce empetriformis | - | - | - | II | - | - | II | - |
| Phyllodoce glanduliflora | - | - | - | II | - | - | II | - |
| Chimaphila umbellata | II | II | - | - | - | - | - | - |
| Monotropa hypopitis | II | I | - | - | - | - | - | - |
| Calypso bulbosa | - | II | - | - | - | - | II | - |
| Moneses uniflora | - | - | II | - | - | - | II | - |
| Antennaria rosea | - | - | - | III | - | - | - | - |
| Coptis trifolia | - | - | - | - | - | - | II | - |
| Cypripedium acaule | - | - | - | - | - | - | II | - |
| Trientalis borealis | - | - | - | - | - | - | II | - |

* Cladonietum: as listed in Table 1. At high altitudes also: Thamnolia subuliformis, Stereocaulon paschale, and Baeomyces sp. See also text.

** Pleurozium community: as listed in Table 1. In addition: Brachythecium turgidum, B. starkei; Ditrichum flexicaule; Hypnum revolutum; Orthotrichum speciosum; Rhytidiadelphus triquetrus; Rhytidium rugosum; Timmia austriaca, and Tortella tortuosa. See also text.

The s p i r a e e t o s u m is commonly in the Cypress Hills, but could not be distinguished in the Rocky Mountains, although *Spiraea lucida* occurs there as well. However, whereas the species was common in the Cypress Hills, and sometimes locally dominant in the shrub layer, elsewhere it was much less common and usually of low cover. The moss and lichen cover is locally well developed, with the "C l a d o n i e t u m" usually occurring as the "multiformis" form, with sparse *Stereocaulon tomentosum*.

The c a l a m a g r o s t i e t o s u m occurs in the Cypress Hills and southern Rocky Mountains, and is characterized by the abundance of *Calamagrostis rubescens* in the groundcover. The bryophyte cover is mostly sparse, and lichens are very sparse or absent.

In the northern parts of the Rocky Mountains, *Hedysarum alpinum* is often an important part of the groundcover, and occasionally abundant. It appears that its presence is indicative of somewhat better moisture conditions, and the h e d y s a r e t o s u m is then primarily an ecological phenomenon. It may be noted that *H. alpinum* is also present in the boreal pine forests, but never in great abundance. Bryophyte and lichen cover, although highly constant, are seldom in excess of 20–30 %.

In the southern parts of the Rocky Mountains, mostly at altitudes above 1500 m, the m e n z i e s i e t o s u m can be encountered. It is characterized by the high cover, up to 3–4, of *Menziesia ferruginea* in the shrub layer. In many of the stands of this subassociation the rare *Rhododendron albiflorum* is also present. The bryophyte cover is often considerable, but lichens are seldom abundant.

The p s e u d o t s u g e t o s u m is well characterized by the Douglas fir, *Pseudotsuga menziesii*, an is a relatively uncommon occurrence. All stands examined are at 1000–1800 m altitude. A very similar community, but with *Pinus flexilis* instead of *P. contorta*, is mentioned by ACHUFF & CORNS (1982) for Banff National Park. I have not seen any stands as described by these authors, but its floristic composition as given would place it as an association in the alliance P i c e i o n g l a u c a e. None of the stands examined had a well developed "C l a d o n i e t u m" cover, although a very sparse lichen cover might be present. Mosses are also rare in this community.

The p i c e e t o s u m a l b e r t i a n a e is common and a widespread community. Stands occur throughout the Rocky Mountains at altitudes of about 1500–2200 m. Several variants can be distinguished on the basis of dominance of species in the shrub, herb, or bryoid layers. One of the more common variants is characterized by the abundance or dominance of *Shepherdia canadensis* in the shrub layer. Another common variant has *Hylocomium splendens* as dominant of the bryoids, a third variant is characterized by the abundance of *Phyllodoce empetriformis* or *Empetrum nigrum* in the groundcover.

At subalpine altitudes, 1800–2500 m, stands of the p i n e t o s u m a l b i c a u l i s can be found. Most of the stands are more or less open, with canopy cover usually less than 80 %. The density of the shrub layer is very variable, ranging in cover from 20 % to more than 50 %. The herbaceous cover varies in composition with the combined cover of the tree and shrub layers. Where both are open, the herbaceous cover contains numerous elements of the surrounding grassland, and *Festuca* spp., including *F. campestris*, may be important constituents.

In stands with a relatively closed canopy, mountain heather may be important in the groundcover, especially *Phyllodoce* and *Cassiope*. Mosses and lichens are sparse or absent.

### Alliance Piceo marianae - Laricion laricinae

The bog forests of the Prairie Provinces, and probably of most of northern North America, can be placed in this alliance. Well developed bog forest is usually dominated by *Picea mariana* with *Larix laricina* as an important part of the tree cover (Table 3). The exception is where the forest developed on rock outcrops of the Canadian Shield. In these forests *P. mariana* is usually the only tree present.

The shrubby layer in bog forests is usually derived from either Salicetea or Oxycocco-Sphagnetea communities. The groundcover almost always consists of a well developed bryoid layer, dominated by *Sphagna* with locally high cover of "Cladonietum". In many stands *Icmadophila ericetorum* can be locally abundant.

The black spruce forests of the Prairie Provinces are of considerable economic importance. Despite the slow growth of the trees, and low yield per hectare, the large areas occupied by the bog forests make these a very important asset. Most of the wood harvested is used for pulp for the paper industry, with only a small percentage used for sawtimber. The shallow root systems of the trees make the bog forest very sensitive to strong winds, and logging or other disturbances often result in uprooting of many trees (Photo 3).

**Photo 3. Many black spruces growing over Precambrian rock outcrops have a shallow root system, and may be uprooted after logging and in windstorms.**

Table 3. Association table of Piceo marianae-Laricion laricinae.

| Subassociation or variant | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Number of relevés | 23 | 20 | 26 | 21 | 23 | 23 | 28 |
| **Association LEDO-PICEETUM MARIANAE** | | | | | | | |
| 1. **typical** variant | | | | | | | |
| K Ledum palustre | **V.2** | V.2 | II.+ | II.+ | II.+ | I.+ | III.1 |
| K Chamaedaphne calyculata | **V.1** | V.1 | I.+ | I.+ | I.+ | I.+ | I.+ |
| d Picea glauca | **V.1** | I.+ | I.+ | - | - | - | II.+ |
| d Symphoricarpos albus | **IV.+** | - | - | - | - | - | - |
| 2. **Arceuthobium** variant | | | | | | | |
| d Arceuthobium pusillum | - | **V.?** | - | - | - | - | - |
| d Viburnum rafinesquianum | I.+ | **IV.1** | - | - | - | - | II.+ |
| d Taxus canadensis | - | **III.+** | - | - | - | - | - |
| d Sphagnum centrale | - | **III.+** | I.+ | - | - | - | I.+ |
| 3. Association **PICEO MARIANAE-LARICETUM LARICINAE** | | | | | | | |
| K Larix laricina | I.+ | I.+ | **V.2** | **V.1** | **V.1** | - | III.+ |
| **Subassociation pinetosum divaricatae** | | | | | | | |
| 4. **Pinus banksiana** variant | | | | | | | |
| d Pinus banksiana | - | - | - | **V.1** | - | II.+ | - |
| d Alnus incana | - | - | - | **V.2** | - | - | - |
| d Trientalis europaea | - | - | - | **IV** | - | - | - |
| 5. **Pinus contorta** variant | | | | | | | |
| d Pinus contorta latifolia | - | - | - | - | **V.2** | - | - |
| d Vaccinium scoparium | - | - | - | - | **V.2** | - | - |
| d Anemone richardsonii | - | - | - | - | **V.1** | - | - |
| 6. Association **BETULO-PICEETUM MARIANAE** | | | | | | | |
| K Betula glandulifera | - | - | - | - | - | **V.2** | - |
| K Salix myrtillifolia | - | - | - | - | - | **IV.1** | - |
| 7. Association **KALMIO-PICEETUM MARIANAE** | | | | | | | |
| K Kalmia polifolia | - | - | I.+ | - | - | - | **V.1** |
| **Alliance PICEO MARIANAE-LARICION LARICINAE** | | | | | | | |
| K Picea mariana | **V.3** | **V.3** | **V.3** | **V.3** | **V.3** | **V.3** | **V.3** |
| K Sphagnetum* | **V.4** | **V.3** | **V.4** | **V.4** | **V.4** | **III.2** | **V.4** |
| **Order & Class** | | | | | | | |
| O Cornus canadensis | IV | IV | III | III | III | IV | III |
| O Pyrola asarifolia | III | III | III | II | III | IV | II |
| O Maianthemum canadense | III | III | III | II | II | III | I |
| O Mitella nuda | IV | IV | IV | IV | III | III | IV |
| O Trientalis borealis | V | IV | IV | III | III | III | III |
| O Pyrola virens | III | II | II | II | II | III | II |
| C Arctostaphylos uva-ursi | V | V | IV | IV | III | IV | IV |
| C Cornus alba stolonifera | III | III | II | II | II | IV | II |
| C Rubus idaeus aculeatissimus | III | III | I | I | - | IV | II |
| C Vaccinium vitis-idaea | V | V | IV | IV | IV | V | V |
| C Pyrola secunda | IV | IV | IV | III | IV | III | III |
| C Epilobium angustifolium | IV | IV | III | III | II | III | I |
| C Linnaea borealis americana | V | V | V | V | V | III | V |
| C Galium triflorum | II | I | - | - | I | III | I |
| **Class OXYCOCCO-SPHAGNETEA** | | | | | | | |
| Andromeda polifolia | III | III | - | - | - | II | III |
| Arctostaphylos alpina rubra | III | I | II | IV | IV | - | II |
| Drosera rotundifolia | III | III | III | II | II | III | IV |
| Gaultheria hispidula | II | IV | III | III | I | I | III |
| Oxycoccus palustris | III | III | III | II | II | I | IV |
| Rubus acaulis | III | III | III | III | III | III | IV |
| Rubus chamaemorus | IV | IV | II | II | II | III | IV |
| Carex capitata | III | III | II | II | I | I | III |
| Carex chordorrhiza | II | I | II | II | - | - | II |
| Carex gynocrates | III | III | I | I | I | - | III |
| Eriophorum vaginatum spissum | III | III | IV | III | II | II | IV |
| Eriophorum angustifolium | II | III | III | III | III | I | III |

Table 3. cont.

| Subassociation or variant<br>Number of relevés | 1<br>23 | 2<br>20 | 3<br>26 | 4<br>21 | 5<br>23 | 6<br>23 | 7<br>28 |
|---|---|---|---|---|---|---|---|
| Accompanying species: | | | | | | | |
| Betula papyrifera | II.+ | II.+ | II.+ | II.+ | I.+ | II.+ | I.+ |
| Populus tremuloides | II.+ | II.+ | I.+ | I.+ | - | II.+ | I.+ |
| Populus balsamifera | I.+ | I.+ | II.+ | II.+ | - | II.+ | - |
| Shepherdia canadensis | II.+ | II.+ | II.+ | II.+ | II.+ | III.+ | I.+ |
| Salix glauca | I.+ | I.+ | II.1 | II.+ | II.1 | II.1 | I.+ |
| Salix pedicellaris | III.+ | II.+ | III.+ | II.+ | II.+ | I.+ | III.+ |
| Rosa acicularis | II.+ | II.+ | II.+ | II.+ | II.+ | II.+ | - |
| Potentilla fruticosa floribunda | III.1 | III.+ | II.+ | II.+ | III.1 | II.+ | - |
| Salix monticola | I.+ | I.+ | I.+ | I.+ | - | II.+ | - |
| Viburnum rafinesquianum | I.+ | I.+ | - | I.+ | - | I.+ | - |
| Viburnum edule | I.+ | I.+ | - | - | - | II.+ | - |
| Juniperus communis | II.+ | II.+ | - | - | - | II.+ | - |
| Juniperus horizontalis | I.+ | I.+ | - | - | - | II.+ | - |
| Salix bebbiana | II.+ | I.+ | - | - | - | II.+ | - |
| Lonicera oblongifolia | I.+ | I.+ | - | - | - | I.+ | - |
| Lonicera involucrata | II.+ | - | - | - | - | II.+ | - |
| Calamagrostis canadensis | II | II | III | II | II | II | III |
| Muhlenbergia glomerata cinnoides | II | II | II | II | I | II | - |
| Elymus innovatus | - | - | I | II | II | - | - |
| Oryzopsis asperifolia | - | - | - | I | I | II | - |
| Deschampsia caespitosa | I | I | - | - | - | II | - |
| Glyceria borealis | - | - | II | - | - | I | II |
| Carex lasiocarpa | II | II | II | II | I | I | II |
| Carex disperma | II | II | II | I | I | - | II |
| Carex curta | I | I | I | - | - | II | I |
| Carex aquatilis | I | I | - | - | - | II | - |
| Carex magellanica | I | I | - | - | - | - | II |
| Equisetum pratense | II | II | III | III | III | II | I |
| Equisetum scirpoides | III | III | III | III | III | II | III |
| Equisetum sylvaticum | II | II | I | II | I | I | II |
| Equisetum variegatum | - | - | - | - | - | II | - |
| Lycopodium annotinum | I | I | - | I | - | I | - |
| Lycopodium complanatum | I | I | - | I | I | - | - |
| Petasites palmatus | II | II | II | II | II | I | I |
| Zygadenus elegans | I | I | I | I | I | II | I |
| Smilacina trifolia | II | II | II | II | II | - | II |
| Habenaria orbiculata | I | I | II | II | II | - | II |
| Habenaria hyperborea | I | I | II | I | II | - | I |
| Orchis rotundifolia | I | I | I | I | I | - | II |
| Anemone parviflora | II | II | II | II | II | I | - |
| Potentilla palustris | II | II | I | I | I | - | I |
| Sarracenia purpurea | II | I | - | - | - | - | I |
| Geocaulon lividum | I | I | - | - | - | II | - |
| Mertensia paniculata | I | I | - | - | I | - | - |
| Vicia americana | I | I | - | - | I | - | - |
| Pedicularis groenlandicum | I | I | - | - | III | - | - |
| Empetrum nigrum | II | II | - | - | - | - | - |
| Lilium philadelphicum | II | II | - | - | - | - | - |
| Parnassia palustris | II | I | - | - | - | - | - |
| Polygonum viviparum | I | I | - | - | - | - | - |
| Lathyrus ochroleucus | I | I | - | - | - | - | - |
| Moneses uniflora | I | I | - | - | - | - | - |
| Parnassia fimbriata | I | - | - | - | I | - | - |
| Pinguicula vulgaris | I | - | - | - | I | - | - |

* Sphagnetum includes: Sphagnum fuscum, S. magellanicum, S. angustifolium, S. warnstorfii, S. riparium, S, squarrosum; Barbilophozia lycopodioides; Lophozia ventricosa. Also, and especially in Betulo-Piceetum, where the first four mosses usually predominate: Aulacomnium palustre; Polytrichum commune; Tomenthypnum nitens; Dicranum polysetum Pleurozium schreberi; Hylocomium splendens; Ptilium crista-castrensis; Drepanocladus uncinatus.

Black spruce reaches maturity at an average age of 125 years; at that age its growth in height ceases, with an average height on the best quality site 15–17 m, with a diameter of 16–20 cm, and a yield of less than 200 $m^3$/ha. The annual increment at the "rotation age" (75–120 yrs) can be as high as 2.0–2.5 $m^3$/ha on relatively fertile, moderately well-drained sites, but declines to 1.0–1.5 $m^3$/ha on poorly drained sites, and to little more than 0.5 $m^3$/ha on infertile, poorly drained sites. Annual increments also decline with increasing age of the trees (KABZEMS 1953; KABZEMS et al. 1976).

### Association Ledo-Piceetum marianae

Stands of this association are most common on sand and sandy loam soils, and are superficially dry. Many of the soils in southeastern Manitoba are of these textures, and the association is prevalent in parts of that area. Two variants of the association can be distinguished (Table 3), primarily based on the distribution of several species that are limited to southeastern Manitoba.

The only form of the association occurring in the northern parts of the Boreal forest zone is the typical variant. The scarcity of *Larix laricina* and frequent presence of *Picea glauca* is perhaps the most characteristic feature of well developed stands. Usually, analyses of the substrates of associations in the alliance do not indicate any differences in pH and nutrients greater than the variability within each association. It seems possible that past disturbances have played an important rolt in causing drying out of the substrate.

The number of trees of *Picea glauca* in mature stands, of 60–80 years of age, is usually in the order of 10–15 % of the total number of trees, which is in the order of 7500 trees/ha, about 80 % of which are black spruce, and 75 % of the trees are less than 80 mm in diameter. In comparison, the number of white spruce in young, less than 40 years old, L e d o - P i c e e t u m stands, is in the order of 3–5 %, while in old stands of more than 120 years old this decreases to only 0.5–1.5 %. In both age classes black spruce contributes about 95 % of the tree density, but the total number of trees at the high age averages 3000/ha, about 40 % of that of the young stands. The average diameter of trees in the young stands is about 40 mm, that in the old stands about 100 mm.

Most of the mature white spruces in black spruce stands are considerably younger than the black spruces, often averaging less than 40 mm in diameter, and about 60 % of the median age of the black spruces. Seddlings and saplings of white spruce are often numerous, but few survive to maturity.

The variant occurring in much of southern Manitoba has the parasite *Arceuthobium pusillum* as one of its differential species. The frequency and abundance of this species are difficult to assess, as the plants are inconspicuous and easily overlooked, and unlike the much larger *A. americanum*, does not cause the conspicuous "witches broom". The distribution of this parasite was discussed by KUIJT (1963), and appears to be limited in our region to a relatively small part of Manitoba, and a small area in eastern Saskatchewan. Although in western Ontario *Thuja occidentalis* occurs in this variant, I have not seen this species in any of the stands in Manitoba.

### Association Piceo marianae-Laricetum laricinae

In stands of the typical form of this association *Picea mariana* forms at least 50 to 60 % of the tree cover, with *Larix laricina* contributing 20–30 % (Photo 4). Locally, however, either tree species may form almost pure stands on small areas, particularly where a catastrophic occurrence has affected one of the species adversely. Thus, *L. laricina* may dominate in areas where black spruce has been subject to strong winds and large numbers of spruces have been uprooted. The aspect of the herbaceous cover in these areas is often dominated by *Eriophorum* spp., and especially on moderately well-drained soils these species may become predominant in the cover.

The bryophyte cover is composed primarily of *Sphagnum*, usually with *S. angustifolium* predominating. Lichens are relatively sparse, but the C l a d o n i e t u m a l p e s t r i s (LOOMAN 1964a, b) can locally form 100 % cover, usually with both *Cladonia alpestris* and *C. rangiferina* predominant.

The p i n e t o s u m d i v a r i c a t a e occurs on the driest areas, with *Pinus* often replacing a considerable part of *Larix*. As stands of the subassociation can occur in both the Boreal forest zone and in the Rocky Mountains, two variants of the subassociation can be recognized, distinguished by the two species of pine and usually several herbs and mosses.

Photo 4. The tamarack or larch, *Larix laricina*, characterizes the association Piceo marianae-Laricetum.

### Association Betulo-Piceetum marianae

Stands of this association occur throughout the area. The shrub layer in this association is characterized by the presence, and usually dominance, of *Betula glandulifera*, usually with an admixture of one or more *Salix* spp., in the shrub layer. Ericaceous shrubs are greatly reduced in abundance when present, but are often absent altogether. The bryoid layer is usually shallow, the depth averaging less than 15 cm. It is commonly dominated by acrocarpous mosses, often with *Aulacomnium* or *Polytrichum* very abundant, *Tomenthypnum* abundant, and *Sphagnum* as a minor constituent or absent. The lichen cover is usually sparse and consists of several small isolated patches, with the drier forms of the "Cladonietum" predominating.

### Association Kalmio-Piceetum marianae

As indicated by the name, the shrub layer of this association is composed of ericaceous shrubs, with *Kalmia polifolia* as a frequent and often dominant constituent. The shrub and subshrub cover can vary considerably, ranging from a low of about 20 % to a high of 60 %. The bryoid layer is dominated by *Sphagnum* spp., and usually forms a closed carpet. The lichen cover can be locally very high, often reaching 60 or 70 %, with wetter forms of the "Cladonietum", represented by *Cladonia rangiferina* and *C. alpestris*, commonly dominant.

### Alliance Piceion glaucae

The forests of the Prairie Provinces classified as Piceion glaucae may be regarded as "climax" vegetation, in one form or another succeeding all other vegetation types, given undisturbed development. In most of the stands examined the origin of the forest was still easily recognizable, and most of the subassociations express this fact. It would have been possible, and perhaps even desirable, to describe several variants in the subassociations, but in most instances the number of relevés was not large enough to ascertain repeated occurrence of the variants.

### Association Vaccinio-Piceetum glaucae

The Boreal white spruce forests of Manitoba and Saskatchewan, as well as those of northern Alberta, belong to this association (Table 4). The forests are usually uniform, i.e., recognizable as belonging to a given subassociation, over considerable areas, usually extending over at least several hectares. However, this uniformity is limited to the arboreal layer; the shrubby, herbaceous, and cryptogamic layers are often rather variable and, as noted earlier, it would be quite possible to describe one or more variants in each of the subassociations on the basis of this variability.

Probably the most common, if not the most extensive in area, is the subassociation typicum. The constancy of *Populus* and *Betula* in stands of this subassociation indicates that direct succession of Populetalia communities is

Table 4. Association table of Vaccinio-Piceetum glaucae.

| Subassociation | 1 | 2 | 3a | 3b | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| Number of relevés | 30 | 21 | 23 | 22 | 25 | 20 | 18 |
| **1. Subassociation typicum** | | | | | | | |
| D Populus tremuloides | **V.1-2** | V.+-1 | II. + | II. + | I. + | I. + | IV.+-1 |
| D Betula papyrifera | **V.1-2** | V. + | IV. + | II. + | II.+-1 | I.+-1 | I. + |
| D Populus balsamifera | **V.+-1** | IV. + | I. + | I. + | I. + | II. + | II.+-1 |
| D Petasites vitifolius | **IV** | II | - | - | - | - | I |
| **2. Subassociation abietetosum balsameae** | | | | | | | |
| D Abies balsamea | II. + | **V.1-2** | - | - | - | I. + | II.+-1 |
| D Lycopodium clavatum | II. + | **V.+-2** | - | - | - | - | I. + |
| D Ledum palustre | II. + | **IV.+-1** | - | - | II.+-1 | II. + | - |
| **3. Subassociation pinetosum divaricatae** | | | | | | | |
| D Elymus innovatus | II. + | I. + | **V.+-1** | **V.+-1** | - | - | - |
| D Oryzopsis pungens | - | - | **III.+-1** | **II.+-1** | - | - | - |
| D Danthonia spicata | - | - | **III. +** | **III. +** | - | - | - |
| D Festuca ovina saximontana | - | - | **III. +** | **II. +** | - | - | - |
| **3a. Pinus banksiana variant** | | | | | | | |
| d Pinus banksiana | I. + | - | **V.1-2** | - | - | - | I. + |
| d Potentilla tridentata | - | - | **IV. +** | - | - | - | - |
| **3b. Pinus contorta variant** | | | | | | | |
| d Pinus contorta | - | - | - | **V.1-2** | - | - | - |
| d Spiraea lucida | - | - | - | **IV.+-1** | - | - | - |
| **4. Subassociation piceetosum marianae** | | | | | | | |
| D Picea mariana | I. + | I. + | - | - | **V.1-2** | - | - |
| D Larix laricina | - | - | - | - | **II. +** | - | - |
| D Chamaedaphne calyculata | - | - | - | - | **IV.+-2** | - | - |
| D Andromeda polyfolia | - | - | - | - | **IV. +** | - | - |
| **5. Subassociation equisetetosum** | | | | | | | |
| D Equisetum arvense | I. + | I. + | - | - | II. + | **V.1-2** | I. + |
| D Equisetum pratense | I. + | II. + | - | - | I. + | **V.1-2** | I. + |
| D Ribes triste | - | I. + | - | - | II. + | **IV.+-1** | - |
| **6. Subassociation thujetosum occidentalis** | | | | | | | |
| D Thuja occidentalis | - | - | - | - | - | - | **V.+-1** |
| D Pinus strobus | - | - | - | - | - | - | **III.+-1** |
| D Diervilla lonicera | - | - | - | - | - | - | **III.+-1** |
| **Association VACCINIO-PICEETUM GLAUCAE** | | | | | | | |
| K Picea glauca | **V.3-4** | **V.2-3** | **V.2-3** | **V.2-3** | **V.2-3** | **V.3-4** | **V.2-3** |
| **Alliance, Order and Class** | | | | | | | |
| V Rubus pubescens | IV.+-1 | IV.+-1 | II. + | II. + | III. + | IV.+-1 | IV.+-1 |
| V Aralia nudicaulis | V | V | V | V | III | IV | III |
| V Arnica cordifolia | V | V | IV | II | III | IV | III |
| V Petasites palmatus | V | IV | III | III | IV | IV | IV |
| V Carex trisperma | V | V | III | II | V | V | III |
| V Equisetum sylvaticum | V | V | III | III | III | V | V |
| V Dryopteris cristata | V | V | III | III | III | V | V |
| O Cornus canadensis | V | V | V | V | V | V | V |
| O Pyrola asarifolia | V | V | V | V | V | V | V |
| O Maianthemum canadense | V | V | V | V | IV | V | V |
| O Mitella nuda | V | V | V | V | V | V | IV |
| O Trientalis borealis | V | V | V | V | V | V | III |
| O Pyrola virens | V | V | IV | III | III | III | IV |
| C Vaccinium angustifolium myrtilloides | V.+-1 | II.+-1 | V.+-1 | III.+-1 | III. + | II. + | III. + |
| C Arctostaphylos uva-ursi | V | III | V | V | IV | II | V |
| C Cornus alba stolonifera | III | V | V | V | V | IV | V |
| C Rubus idaeus aculeatissimus | III | V | III | II | V | V | IV |
| C Vaccinium vitis-idaea | III | III | III | III | IV | III | IV |
| C Pyrola secunda | V | V | V | V | V | V | V |
| C Epilobium angustifolium | V | V | V | V | V | V | V |
| C Linnaea borealis | V | V | V | V | V | V | V |
| C Galium triflorum | III | III | II | III | V | V | III |
| C Pleurozium community* | V | V | V | V | V | V | V |

Table 4. cont.

| Subassociation<br>Number of relevés | 1<br>30 | 2<br>21 | 3a<br>23 | 3b<br>22 | 4<br>25 | 5<br>20 | 6<br>18 |
|---|---|---|---|---|---|---|---|
| Accompanying species: | | | | | | | |
| Shepherdia canadensis | II. + | I. + | I. + | I. + | I. + | II. + | II. + |
| Rosa acicularis | V. + | V. + | III. + | IV. + | II. + | I. + | IV. + |
| Viburnum edule | V.+-1 | V.+-1 | IV.+-1 | III. + | III. + | III. + | V.+-1 |
| Salix bebbiana | III. + | III. + | IV. + | II. + | III. + | IV. + | III. + |
| Rubus idaeus aculeatissimus | IV.+-1 | IV.+-1 | I. + | I. + | III. + | III. + | IV.+-1 |
| Alnus incana | III. + | III. + | II. + | II. + | III. + | III.+-1 | II. + |
| Ribes americanum | III. + | I. + | I. + | I. + | I. + | - | II. + |
| Lonicera involucrata | III. + | II. + | I. + | I. + | I. + | - | I. + |
| Prunus pensylvanica | III. + | I. + | I. + | - | - | - | II. + |
| Amelanchier alnifolia | I. + | I. + | - | - | - | - | I. + |
| Lonicera oblongifolia | I. + | I. + | - | - | - | - | I. + |
| Corylus cornuta | I. + | I. + | - | - | - | - | I. + |
| Symphoricarpos albus | I. + | I. + | - | - | - | - | I. + |
| Salix discolor | I. + | I. + | - | - | - | - | I. + |
| Juniperus communis | II. + | - | II. + | III.+-1 | - | - | - |
| Chimaphila umbellata | II.+-1 | - | I. + | II. + | - | - | - |
| Salix lutea | II.+-1 | - | I. + | - | - | - | - |
| Alnus viridis | - | - | II. + | II. + | - | I. + | - |
| Potentilla fruticosa floribunda | - | - | I. + | II. + | - | - | I. + |
| Gaultheria hispidula | - | - | - | - | II | - | - |
| Oxycoccus palustris | - | - | - | - | II | - | - |
| Agropyron trachycaulum | III | III | II | II | III | II | II |
| Cinna latifolia | IV | IV | II | I | I | II | III |
| Schizachne purpurascens | IV | IV | III | III | II | II | III |
| Oryzopsis asperifolia | III | III | III | IV | III | I | III |
| Bromus pumpellianus | II | II | II | II | I | I | - |
| Calamagrostis rubescens | II | II | - | II | - | II | - |
| Poa pratensis | II | I | I | - | - | - | - |
| Poa nemoralis | I | II | - | - | - | - | - |
| Equisetum scirpoides | II | II | I | II | III | II | II |
| Lycopodium annotinum | III | III | I | I | II | I | III |
| Lycopodium complanatum | II | II | I | II | I | I | II |
| Lycopodium obscurum | III | III | I | - | - | - | II |
| Fragaria virginiana | V | IV | III | III | IV | IV | IV |
| Lathyrus ochroleucus | IV | II | IV | II | III | II | III |
| Mertensia paniculata | V | III | III | II | I | II | III |
| Geocaulon lividum | I | I | I | II | II | I | II |
| Vicia americana | II | I | I | - | II | - | I |
| Pyrola rotundifolia | II | II | II | - | I | - | I |
| Aster ciliolaris | II | I | II | II | I | II | I |
| Aster conspicuus | I | I | I | II | - | I | - |
| Moneses uniflora | I | I | - | - | I | I | I |
| Actaea rubra | III | II | II | II | - | - | - |
| Campanula rotundifolia | II | I | III | II | - | - | - |
| Pyrola minor | II | II | - | - | - | - | II |
| Matteuccia struthiopteris | II | II | - | - | - | - | II |
| Goodyera repens | II | II | - | I | - | - | II |
| Habenaria obtusata | II | - | - | - | II | - | - |
| Coptis trifolia | II | I | - | - | - | - | - |
| Corallorhiza maculata | II | I | - | - | - | - | - |
| Corallorhiza trifida | II | - | II | II | - | - | - |
| Cypripedium acaulum | I | - | II | I | - | - | - |
| Sanicula marilandica | II | - | - | - | - | - | - |
| Thalictrum venulosum | II | - | - | - | - | - | - |
| Heracleum lanatum | - | - | II | I | - | - | - |
| Melampyrum ciliare | - | - | II | II | - | - | - |
| Dryopteris thelypteris | - | - | - | - | II | II | - |
| Pteridium aquilinum | - | - | - | - | - | - | II |

* Pleurozium community includes: Hylocomium splendens; Pleurozium schreberi; Drepanocladus uncinatus, D. revolvens; Dicranum polysetum, D. scoparium; Ptilium crista-castrensis; Polytrichum commune, P. norvegicum, P. juniperinum; Thuidium abietinum; Pylaisia polyantha; Ptilidium pulcherrinum, P. ciliare; Lophozia lycopodioides; Blepharostoma trichophyllum.

often involved. This is also evident after catastrophic disturbances, when the broad-leaved trees take over and occupy the open spaces created. Seedlings of *Picea glauca* often begin to establish in P o p u l e t a l i a stands when the deciduous trees are 10–15 years old (KABZEMS 1971).

The vigour of the deciduous species, in particular *Populus tremuloides*, is often surprising. Thus, after clearing of forest for road construction a belt of *P. tremuloides* is soon in evidence (Photo 5), although the species is represented in the undisturbed spruce forest by only a few small, weak shoots, often only 2–3 cm in diameter, and 1.0–1.8 m tall.

Photo 5. Soon after severe disturbances, as road construction, the vigour of aspen, *Populus tremuloides*, becomes evident.

One area of spruce forest in Manitoba, the "Spruce Woods Forest Reserve", may be considered a variant of the t y p i c u m; it is in an area of wet sand dunes, and *Chimaphila umbellata* is abundant in the herb layer. In favourable years the number of spruce seedlings in this forest may reach $100^{+}/m^{2}$ in spring, but only a few of these survive into the fall; most seedlings are eaten by rabbits. The apparent former occurrence of white spruce in the Great Sandhills of southwestern Saskatchewan (LOOMAN 1987), reported by early settlers in that area, may have been a similar forest type.

The a b i e t e t o s u m b a l s a m e a e is limited to the higher elevations in the southern parts of the Boreal forest zone, and to higher latitudes in general. However, this does not mean that *Abies* is indicative of, or restricted to, cooler areas. In several relevés of the other subassociations throughout the region in

which *Abies* occurred, the species was present only as saplings in the shrub layer, and as seedlings in the herbaceous cover.

The relative rarity of the abietetosum is probably due to the fact that clearcutting prevented reestablishment of the species in large areas. Also, in many areas *Abies* was cut selectively, mainly in easily accessible parts of the region. The present apparent distribution of the species, and the communities in which it occurs, is therefore somewhat misleading. Both the abundance of *A. balsamea* and the extent of the subassociation abietetosum may well be the result of human actions.

The pinetosum divaricatae can be divided into two variants, with *Pinus banksiana* and *P. contorta*, both with accompanying species, as diagnostic differential species. In the P. banksiana variant the cryptogamic cover is usually more developed, and has greater cover, than in the P. contorta variant. In both variants it consists of the *Pleurozium* community, often with remnants of the "Cladonietum", with several species of *Cladonia*, including *C. mitis* and *sylvatica* as well as *Peltigera aphthosa*.

The P. contorta variant, as it occurs in the northern Rocky Mountains and high elevations in northwestern Alberta, is very similar to its counterpart in Saskatchewan and Manitoba. The greatest difference between the two variants is found in the southern Rocky Mountains, and in the Cypress Hills in Alberta, although in the latter the area of the variant is small, and no relevés were taken there because of the small size of the stands.

The piceetosum marianae is distributed in the Boreal forest zone throughout the same regions as the Piceo marianae-Laricion laricinae, and intergrades in most areas with stands of communities in the alliance. The density of the black spruce averages about 8–12 % of the total tree density, but the trees are usually old and large.

Stands of the equisetetosum show a strong ecological similarity to the stands of *Populus balsamifera* in which *Equisetum* spp. form the dominant ground cover. Usually, there is considerable evidence that snow drifts accumulate in the stands, and because of the heavy shading persist until early summer. Although the species density may be rather high, often equalling that in typicum stand, the total cover of *Equisetum* is very high, reaching 70–80 % in many stands, thus leaving little room for other species.

The thujetosum occidentalis is limited to southeastern Manitoba, where it occurs on soils of medium to heavy texture, and on moist sand soils. Together with *Pinus strobus*, *Thuja occidentalis* is a minor component of the "northern mesic forest" of CURTIS (1959), where it also occurs in swampy areas.

### Association Piceetum albertianae

Stands of this association (Table 5) are limited to the eastern slopes of the Rocky Mountains in western Alberta, where they form an important part of the forest vegetation. Spruce forest occupies all altitudinal zones, from about 1000 m to the tree line, varying from about 2500 m in southern parts of the mountains to 2200 m or less in the northern parts. The altitude at which the tree line occurs

Table 5. Association table of Piceetum albertianae.

| Subassociation | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Number of relevés | 22 | 24 | 20 | 20 | 18 | 23 |
| **1. Subassociation typicum** | | | | | | |
| D Populus tremuloides | IV.+-2 | I. + | - | - | - | I. + |
| D Populus balsamifera | IV.+-1 | I. + | - | - | - | I. + |
| D Betula papyrifera | III. + | - | - | - | - | I. + |
| **2. Subassociation abietetosum lasiocarpae** | | | | | | |
| D Abies lasiocarpa | I.+-1 | V.1-2 | II. + | II. + | II. + | IV. + |
| D Menziesia ferruginea | - | V.+-2 | - | III. + | I. + | - |
| D Rhododendron albiflorum | - | IV.+-1 | - | III. + | II. + | - |
| **3. Subassociation pinetosum contortae** | | | | | | |
| D Pinus contorta | II. + | I. + | V.1-2 | I. + | - | II.+-1 |
| D Shepherdia canadensis | V. + | I. + | V.1-2 | I. + | IV. + | - |
| D Solidago multiradiata | II | - | IV | - | - | II |
| **4. Subassociation pinetosum albicaulis** | | | | | | |
| D Pinus albicaulis | - | - | - | V.1-2 | - | - |
| **5. Subassociation pseudotsugetosum** | | | | | | |
| D Pseudotsuga menziesii | - | - | - | - | V.1-2 | - |
| D Aster conspicuus | I | - | I | - | IV | - |
| **6. Subassociation vaccinietosum** | | | | | | |
| D Vaccinium membranaceum | - | III. + | - | II. + | - | V.1-2 |
| D Vaccinium scoparium | - | II. + | I. + | IV. + | - | V.1-2 |
| **Association PICEETUM ALBERTIANAE** | | | | | | |
| K Picea glauca var. albertiana | V.3-4 | V.2-3 | V.2-3 | V.2-3 | V.2-3 | V.3-4 |
| **Alliance, Order and Class** | | | | | | |
| V Rubus pubescens | V.+-1 | III. + | III. + | I. + | I. + | IV.+-1 |
| V Arnica cordifolia | III | IV | III | II | II | IV |
| V Petasites palmatus | IV | IV | III | I | II | V |
| O Cornus canadensis | IV | V | V | II | III | IV |
| O Pyrola asarifolia | IV | III | V | - | III | IV |
| O Maianthemum canadense | IV | III | - | - | III | IV |
| O Mitella nuda | III | III | II | II | III | V |
| O Pyrola virens | IV | IV | II | I | I | IV4 |
| C Vaccinium angustifolium myrtilloides | III. + | V.+-1 | III.+-1 | - | II. + | IV.+-1 |
| C Arctostaphylos uva-ursi | IV | II | III | II | II | III |
| C Rubus idaeus aculeatissimus | III | III | II | I | I | III |
| C Vaccinium vitis-idaea | III | III | I | I | II | IV |
| C Linnaea borealis | IV | III | V | II | III | IV |
| C Pyrola secunda | III | IV | III | II | V | IV |
| C Epilobium angustifolium | III | II | II | I | I | III |
| C Pleurozium community* | V | V | V | I | II | V |
| Accompanying species: | | | | | | |
| Larix lyalli | - | I. + | - | I. + | - | I. + |
| Betula occidentalis | II. + | I. + | - | - | - | 2. + |
| Picea mariana | - | - | - | I. + | - | - |
| Pinus banksiana | - | - | - | - | III.+-1 | - |
| Juniperus communis | II.+-1 | II. + | II.+-1 | II.+-1 | IV.+-2 | II.+-1 |
| Rosa acicularis | V | I | IV | - | V | V |
| Viburnum edule | III | II | III | - | I | III |
| Salix glauca | - | II | - | I | I | I |
| Salix vestita | - | II | - | I | I | II |
| Arctostaphylos alpina rubra | II | II | - | I | - | I |
| Rubus pedatus | - | II | - | I | - | III |
| Betula nana sibirica | - | I | - | I | - | I |
| Ribes americanum | II | - | II | - | - | II |
| Clematis verticellaris | II | - | II | - | II | - |
| Ribes lacustris | II | I | - | - | II | - |
| Cassiope tetragona | - | IV | - | III | - | IV |
| Cassiope mertensiana | - | II | - | II | - | II |
| Empetrum nigrum | - | II | - | II | - | I |
| Phyllodoce empetriformis | - | II | - | II | - | III |
| Phyllodoce glanduliflora | - | II | - | I | - | IV |
| Dryas octopetala | - | II | - | I | - | II |

Table 5. cont.

| Subassociation<br>Number of relevés | 1<br>22 | 2<br>24 | 3<br>20 | 4<br>20 | 5<br>18 | 6<br>23 |
|---|---|---|---|---|---|---|
| Salix bebbiana | III | - | I | - | - | - |
| Lonicera dioica | II | - | II | - | - | - |
| Amelanchier alnifolia | II | - | I | - | - | - |
| Lonicera involucrata | II | I | - | - | - | - |
| Spiraea lucida | - | - | II | - | IV | - |
| Ledum palustre | - | IV | - | III | - | - |
| Cornus alba stolonifera | III | - | - | - | - | - |
| Prunus virginiana | III | - | - | - | - | - |
| Elymus innovatus | V | II | V | - | V | I |
| Oryzopsis asperifolia | III | I | III | - | - | III |
| Schizachne purpurascens | III | I | III | - | - | II |
| Calamagrostis rubescens | III | - | - | - | III | - |
| Cinna latifolia | II | - | - | - | - | II |
| Phleum alpinum | - | - | - | - | - | III |
| Trisetum spicatum | - | - | - | - | - | II |
| Carex concinna | I | III | II | - | - | - |
| Carex concinnoides | II | II | - | - | - | II |
| Carex eburnea | - | - | III | - | II | - |
| Carex scirpoidea | II | - | II | - | - | - |
| Carex richardsonii | II | - | I | - | - | - |
| Equisetum scirpoides | III | II | I | - | - | III |
| Equisetum sylvaticum | II | I | I | - | - | III |
| Equisetum pratense | III | - | - | - | - | II |
| Lycopodium annotinum | I | II | - | - | - | I |
| Fragaria virginiana | III | I | I | I | II | I |
| Arnica latifolia | II | II | I | - | - | II |
| Zygadenus elegans | II | - | II | I | - | II |
| Delphinium glaucum | II | II | - | - | - | II |
| Stenanthium occidentale | I | II | - | - | - | III |
| Moneses uniflora | I | II | - | - | - | II |
| Dryas octopetala | - | II | - | I | - | II |
| Erythronium grandiflorum | - | II | - | I | - | II |
| Pedicellaris bracteosa | - | II | - | I | - | I |
| Hedysarum alpinum americanum | - | I | - | II | - | II |
| Antennaria racemosa | - | II | I | - | - | II |
| Antennaria rosea | II | - | II | - | - | I |
| Veratrum eschscholtzii | I | II | - | - | - | II |
| Listera cordata | I | II | - | - | - | I |
| Geocaulon lividum | IV | - | - | - | - | II |
| Lathyrus ochroleucus | III | - | - | - | - | II |
| Vicia americana | III | - | - | - | - | I |
| Mertensia paniculata | II | - | - | - | - | II |
| Angelica dawsonii | - | II | - | - | - | II |
| Valeriana sitchensis | - | I | - | - | - | II |
| Viola orbiculata | - | - | II | - | - | II |
| Trollius albiflorus | - | - | II | - | - | II |
| Coptis trifolia | II | II | - | - | - | - |
| Habenaria hyperborea | I | II | - | - | - | - |
| Aster ciliolaris | II | - | II | - | - | - |
| Aster subspicatus | II | - | I | - | - | - |
| Calypso bulbosa | II | - | II | - | - | - |
| Cypripedium acaule | - | - | II | - | I | - |
| Oxytropis deflexa | II | - | - | - | - | III |
| Oxytropis splendens | II | - | - | - | - | II |
| Astragalus frigidus americanus | I | - | - | - | - | II |
| Aster sibirica | - | - | II | I | - | II |
| Hedysarum sulphurescens | - | - | II | II | - | II |
| Aquilegia flavescens | - | - | II | II | - | I |

*Pleurozium community as in Table 4; in addition: Dicranum brevifolium, D. fuscescens; Distichium capillaceum; Ditrichum flexicaule; Eurhynchium pulchellum; Tortella tortuosa; Rhytiadelphus triquetrus; Timmia austriaca; Barbilophozia hatcheri.

also depends on the exposure of slopes (Photo 6). The subassociations are, to a large extent, expressions of the distribution of species over the altitudinal zones. This will be indicated where appropriate.

Photo 6. The Piceetum albertianae extends on the slopes of mountains up to the tree line, with the altitudinal level depending on exposure.

The development, growth rates, and timber yields of *Picea glauca albertiana* are very similar to that described for the Boreal forests. In lower altitudes, however, precipitation is higher than in the Boreal forest zone, and combines with relatively high temperatures. Trees in these areas show greater annual increments, and hence yields, than are encountered in the Boreal forest zone.

Precipitation amounts increase with increasing altitudes, but at the same time temperatures drop considerably, the growing season is much shorter, and growth rates decrease accordingly. At altitudes above 1800 m precipitation may still fall in the form of snow in mid-June, and may do so again in mid-August. At $2000^+$ m frost may occur at any time of the year. With increasing latitudes, the snow- and frost-free period becomes gradually shorter, and occurs at lower altitudes.

The growth rate of *Abies lasiocarpa* is similar to that of *Picea*, but that of *Pseudotsuga menziesii* is potentially much greater. The latter can produce in excess of 4 $m^3$/ha/year even in the dry areas of interior British Columbia (MITCHELL & GREEN 1981). However, Douglas fir does not now occur in extensive stands. The presence of very large stumps ($120^+$ cm) in areas where the tree is now rare

may indicate that it was much more common in the past, but has been logged out.

The t y p i c u m is common on sandy loam and heavier soils, and is best developed at altitudes of 1200–1500 m. In the southern parts of the Rocky Mountains much of the spruce forest, like the pine forest, is open to summer grazing, and in large areas the shrub and herb layers have been all but eliminated. Spruce seedlings and saplings are very rare in these forests, and incremental growth is low.

Stands of the a b i e t e t o s u m l a s i o c a r p a e occur at higher altitudes of 1500–2000$^+$ m. Especially at high altitudes the groundcover is often dominated by ericaceous shrubs, with *Cassiope* and *Phyllodoce* usually abundant. At lower altitudes, *Vaccinium* spp. are often abundant, and ACHUFF & CORNS (1982) described several ecological vegetation types in this subassociation.

The p i n e t o s u m c o n t o r t a e is most common at intermediate altitudes of 1200–1800 m, and in more southern latitudes. Fully half of the relevés listed in Table 5 were taken in the mountains between 49° and 52°N. It is possible to distinguish at least three variants, based on the occurrence of species limited to high altitudes, or more northern latitudes. Some of the vegetation types described by ACHUFF & CORNS (1982) in the *Pinus contorta* types correspond well to these variants. Some subalpine forest types described by GRIFFITHS (1981, 1982) also fit in variants of this subassociation.

Stands of the p i n e t o s u m a l b i c a u l i s occur at high altitudes of 1800–2200 m. Well developed stands are not common, but appear to be uniform in composition over much of the distribution area of the subassociation. Stands described by ACHUFF & CORNS (1982) from Banff and Jasper National Parks are very similar to those I have seen in the extreme southern part of the range.

Stands of the p s e u d o t s u g e t o s u m occur at lower altitudes of 1000 to 1500 m. As mentioned, *Pseudotsuga* is at present a rather uncommon tree, but may have been much more common in the not too distant past. If this is so, it is quite possible that the species will increase in abundance under the protection against logging in the National Parks, especially in the southern part of the Rocky Mountains. Several fragmentary stands of "open forest" with mostly young trees of *P. menziesii* may eventually form a closed canopy. The lower strata in these stands lack some of the shade requiring herbs, but include grassland species, as *Festuca campestris, F. idaboensis, Campanula rotundifolia, Achillea millefolium*, and others. The bryophyte cover in the majority of stands is sparse, or poorly developed. However, ACHUFF & CORNS (1982) describe one vegetation type with *P. menziesii* in which *Hylocomium splendens* is abundant and used as a "differential species".

The v a c c i n i e t o s u m occurs almost exclusively at altitudes between 1500 and 1800 m, descending to somewhat lower altitudes in the most northern parts of the Rocky Mountains. The low shrub cover is dominated by *Vaccinium* spp., but usually has also a well developed bryophyte cover. ACHUFF & CORNS (1982) recognized several vegetation types in which *Vaccinium* spp. were used as differential species. It would undoubtedly be possible to recognize variants in this subassociation on the basis of dominance of one or another of the *Vaccinium* spp. present, but in some instances a 2500 m$^2$ stand would have belonged

to more than one variant. Hence, it seems rather futile to describe variants that may not be repeated in other areas, and are often of little extent locally. However, the various ecological vegetation types recognized by ACHUFF & CORNS may be of importance from a forestry standpoint.

**Economic importance of the coniferous forest**

Although the harsh climatic conditions in the Boreal forest zone cause slow growth of the trees, the forest plays an important part in the economy of the sparsely populated parts of the Prairie Provinces. White spruce especially has been logged for well over a hundred years in many areas, and it is doubtful that any extensive areas of truly "virgin" forest still exist. Certainly, in the southern parts of the Boreal forest zone most, if not all, of the forest has been exploited at least once, and possibly more than once in some areas.

The annual increments of merchantable timber are low, ranging from less than 0.5 $m^3$/ha/yr to little more than 4.8 $m^3$/ha/yr, averaging about 2.0 $m^3$/ha/yr, for trees of 70–80 years of age, and depending on the species and soil conditions (KABZEMS 1953; KABZEMS & KIRBY 1956; KABZEMS 1971; KABZEMS et al. 1976). This compares with incremental growth in areas with similar precipitation, e.g., the interior of British Columbia of 3–4 $m^3$/ha/yr (MITCHELL & GREEN 1981).

The low yields, combined with the inaccessibility and great distances from inhabited areas of large parts of the forests, result in relatively high exploitation costs, and most of the industry is limited to the southern part of the Boreal forest zone. The recent extension of major roads into northern parts of the Boreal forest has made more of the area accessible, but increased the distance from markets.

In addition to low yields and high exploitation costs, much of the timber is of low quality, and relatively low value. Most of the pine forest is suitable only for pulp-wood, railroad ties, and telephone poles, and the timber is inferior as building material, except for "log cabins". Black spruce is almost exclusively used for pulp-wood. With few exceptions, logging operations are of a small scale, but of great importance to the local economies.

Natural regeneration of the forest after logging is generally poor and not reliable, and planting of seedlings is usually required to achieve proper management of the forest. Regeneration after fire also is usually poor; ground fires often burn off all seedlings, and destruction of large areas of the Boreal forest may result in almost total lack of seed sources of coniferous seedlings, and take-over of large areas by deciduous forest.

Undoubtedly, the white spruce forests are economically the most important vegetation of the Boreal forest zone as well as the Rocky Mountains. These forests yield high quality logs for various purposes, most of the timber for the construction industry, as well as pulp-wood for the paper industry.

One of the main reasons for its great economic importance is that, compared to the black spruce, the growth rate of the white spruce on favourable habitats is very high in the early stages of growth. Also, trees reach maturity at a much greater age, averaging 23–25 m at rotation age of 80–85 years, but can reach heights of 35–40 m, and may have a diameter of 80 cm or more at 180–200

years of age. In some moderately well drained sites on fertile soil diameters of 80–100 cm may be found. Similarly, annual increments depend on site quality, and can range from a low of 1.8 $m^3$/ha/yr on the driest or wettest sites to almost 5.0 $m^3$/ha/yr on the most favourable sites. Although the density of trees in a well-stocked site is low, in the order of 750–800 trees/ha, the total timber yield can reach as much as 450 $m^3$/ha on good quality sites, with about 200 $m^3$/ha on the lowest quality sites (KABZEMS 1971; KABZEMS et al. 1976).

In addition to its importance for the wood products industry, the Boreal forest is also very important for recreational purposes. Several thousands of large and small lakes are situated in the Boreal forest zone (LOOMAN 1986). Most of the largest and, from a recreational standpoint most desirable, lakes are situated in the spruce forests. Many of these lakes have campsites or cabins along their shores in the shelter of the white spruce forest, and are used by hundreds of tourists during the summer months.

As a result, the income from tourism is of great importance in the northern Boreal forest zone, where many communities are almost wholly dependent on tourism during the fishing and hunting seasons. In particular, the outfitters camps and guides for fishing and hunting parties depend for most of their income on the Boreal forest. Adverse weather conditions, and in particular, frequent forest fires, can be disastrous for these enterprises.

Although the fur trade has diminished greatly in value, many people living in the Boreal forest zone still derive most of their income from trapping. More than 50 % of the trappers are native Indians, for whom trapping is the main, and often only, source of income. The decline in importance of the fur industry is in part due to the building of roads, exploration for oil and mines, and the development of hydro-electric works and logging, which has resulted in steadily shrinking populations of fur bearing animals, in a few instances almost to the point of extinction. The effect on the native communities has often been tragic.

Another reason for the decline of the fur trade is the recent resistance to the use of natural fur, and the trapping and hunting of fur bearing animals. The increase in populations of the timber wolf, and depredation of the caribou and moose populations in several areas, e.g., in the northern Rocky Mountains, may well be due to the decreased trapping activity.

## Coniferous forests as biocoenose

Compared to the other vegetation types, and in particular the deciduous forest, the coniferous forest is depauperate as a biocoenose. Both the vertebrate and invertebrate fauna have smaller numbers of species, and only a few of these can be considered unique to the coniferous forest. The same is true for the epiphytic lichens, and only the groundcover is, although not unique in every respect, with several species occurring in various deciduous forest types, typical and best developed in the coniferous forest.

The epiphytic lichen populations found on coniferous trees, especially *Picea*, *Abies*, and *Larix*, are seldom as large and varied as those found on deciduous trees. Only where trees are frequently exposed to moisture laden air several *Usnea* spp., often with *Alectoria* and *Evernia*, can be found, especially on dead branches and

on dead or dying trees. In moist areas the lower part of the stems of trees often has a cover of *Parmeliopsis* spp. and small thalli of *Cladonia* spp.

Pines appear to offer the best substrate for epiphytic lichens, and may have *Cetraria* spp., crustose *Lecanora*, *Lecidea*, and *Buellia*, as well as *Parmelia* and *Physcia* spp. (LOOMAN 1962) covering several of the lower branches. Many old cones also can be covered with several of the species mentioned, and occasionally small thalli of *Usnea* are present.

Several fungi parasitic on conifers occasionally can cause damage to trees and make the wood worthless. Among these are *Fomes* spp., causing "heart rot", and *Stereum* spp., wich cause "stain" in the wood. Branches may harbour many species of micro-fungi; I have found as many as ten species on a single branch, but none of these were identified. It appears that very little is known about this part of the flora.

The frequent abundance of mushrooms in pine forest has already be mentioned. Although mushrooms are much less common in the spruce forests, several of the species found in the pine forest can also be found in moist spruce forests. In addition, *Clavaria* spp., and *Hydnum* spp. can be found in some areas. The macrofungi of the Boreal forest zone are, however, as yet not well known. Recently burned-over forest, especially pine forest, may have an abundance of *Morchella esculenta*.

Insect populations are rarely very large but can take the form of local plagues. Thus, conifer saw flies (Diprionidae) occasionally become abundant, and can do considerable damage to *Larix laricina*. The common species involved is *Neodiprion abietis*. Of the budworms (Tortricidae) *Choristoneura pinus* on pines, and *C. fumiferana* on spruce, can cause some damage. The latter, which has plagued spruce forests in eastern Canada for many years, is seldom abundant in the Prairie Provinces. Scale insects (Coccoidea) occur on all conifers, and the pine needle scale, *Phenacaspis pinifoliae* can be abundant on conifers in gardens.

Of the aphids (Chermidae) *Chermes* spp. may cause some damage to the spruces. Other potentially damaging insects are the larvae of moths (Sphingidae, Geometridae, Arctiidae), some of which are fairly common, including *Sphinx* spp. and *Apantesis virgo*. Species of bark beetles (Scolytidae, Rhysodidae) and wood wasps or horntails (Siricidae) are common on dead and dying trees, and are in turn parasitized by ichneumons (Ichneumonidae), including *Dolichmetus* spp. In sandy areas, primarily in pine forests, several species of ants (Formicidae) are more or less common.

Birds are much less common in the coniferous forests than in the deciduous and mixed forests. In areas where pine or spruce forests have a minimum of admixture of hardwoods, bird populations are not only poor in species, but also small. It is possible to spend several days in one location and observe only three or four species. One of these is likely to be the Canada jay (*Perisoreus canadensis*), and another the boreal chickadee (*Parus hudsonicus*). The blue jay (*Cyanocitta cristata*) is more common in areas of mixed woods, or where deciduous forest is near.

Most of the other birds that can be observed are, like the blue jay, rare in "pure" coniferous forest, and increase in abundance with the proximity of deciduous trees (SALT & SALT 1976). However, several species are more or less

typical for the coniferous forest, nesting in spruce or pine and feeding mostly on conifers. Kinglets (*Regulus satrapus* and *R. calendula*) are occasionally seen in the northeastern parts of the forest. The crossbills (*Loxia curvirostra* and *L. leucoptera*) are more widespread, but nowhere common. Also not common but widespread are the three-toed woodpeckers (*Picoides arcticus* and *P. tridactylus*). Of the birds of prey the hawk owl (*Surnia ulula*), great gray owl (*Strix nebulosa*), and boreal owl (*Aegiolus funereus*), can be encountered deep in the boreal forests.

Several species are more or less common in pine forests, but are seldom met with in the dense spruce forests. The nuthatch (*Sitta canadensis*), brown creeper (*Certhia familiaris*), waxwing (*Bombycilla garrulus*), raven (*Corvus corax*), nighthawk (*Chordeiles minor*), sparrows (*Zonotrichia* spp.), flycatchers (*Tyrannus* spp. and *Empidonax* spp.), evening and pine grossbeaks (*Hesperiphona vespertina* and *Pinicola enucleator*), pine siskin (*Spinus pinus*), and redpolls (*Acanthis hornemannii* and *A. flammea*) are widespread, but seldom common. Cassin's finch (*Carpodacus cassinii*) is restricted to the southern Rocky Mountains, while the purple finch (*C. purpureus*) occurs in the northern Boreal forests.

Populations of mammals, like those of the birds, are small and poor in species. Although a few of the mammals occur primarily in coniferous forests, all can also be found in the mixed woods. Others are much more common in deciduous forest, but appear to avoid only the densest of the coniferous forests (BANFIELD 1974). Still others occur only in certain types of deciduous forest.

Among the latter are the caribou (*Rangifer tarandus caribou*) which, when present, is restricted to lichen rich forests, and the bog lemming (*Synoptomys borealis*), which occurs only in black spruce forest in the extreme northern parts of the Boreal forests. Martens (*Martes americanus* and *M. pennanti*) are more common in coniferous forest, while the ermine and mink (*Mustela erminea* and *M. vison*) appear to prefer the mixed forests. The porcupine (*Erethizon dorsatum*), wolf (*Canis lupus*), black bear (*Ursus americanus*), and lynx (*Lynx lynx*) also can be found in the coniferous forests, but are more likely to be seen in the mixed or deciduous forest areas.

Some of the small mammals, voles (*Phenacomys intermedius mackenzii* and *Clethionomys gapperi athabascensis*), shrews (*Sorex arcticus*), the deer mouse (*Peromyscus maniculatus borealis*), and the bats (*Myotis lucifugus, Lasiurus cinereus* and *L. borealis*) are mostly confined to the margins of and openings in dense forests. All are more common in mixed forest. Red squirrels (*Tamiasciurus hudsonicus preblei*) occur throughout the coniferous forests, as do the flying squirrel (*Glaucomys sabrinus*), chipmunk (*Eutamias minimus borealis*), and woodchuck (*Marmota monax*). These can be encountered throughout the coniferous forests, but are by no means restricted to it. The snowshoe hare (*Lepus americanus*) can do considerable damage to areas of reforestation by girdling saplings and eating seedlings.

Although deer (*Odocoileus* spp.) and especially the moose (*Alces alces*), occur throughout the Boreal forest zone, this forest provides little or no food, and is primarily used as shelter. Because of the large number of lakes and small streams in the area, the beaver (*Castor canadensis*) and muskrat (*Ondutra zebethicus*) also occur throughout the coniferous forests, but mostly in areas where deciduous trees are near.

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Address of the author:
Dr. J. LOOMAN, Research Station, Research Branch, Agriculture Canada, Swift Current, Saskatchewan, S9H 3X2 (Retired)
Present address: P.O. Box 3613, High River, AB. T0L 1B0, Canada.